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Nuts, Bolts and a Bit of Mettle: How Parents Prepare Their Boys and Girls for the STEM Pipeline

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Nuts, Bolts and a Bit of Mettle: How Parents Prepare Their Boys and Girls for the STEM Pipeline

Abstract
The needs for strengthening the STEM pipeline in the United States have moved beyond routine concerns and acquired an unprecedented level of urgency. As a result, many educational and business entities, and government and private organizations have launched myriad initiatives targeted towards achievement of the above goal. The extant body of research, while certainly explicating the essential steps that can be actuated by educational, research, and legislative entities, has largely left out the potential role of parents. Accordingly, the primary question guiding this research was: How do parents prepare their boys and girls for the STEM pipeline? What is the range and variation of support given by fathers and mothers to their children for exploring and entering STEM fields?

Based on this study's findings, I posit that parents extend support through a model of "AID: Adaptive, Incidental, and Deliberate Practices" representing the totality of their choices, decisions, perspectives, actions, and interventions. The study reveals parents' efforts within an evolving pattern of noteworthy transitions, commencing from children's early childhood years and lasting through high school. Finally, this study has identified a unique combination of characteristics underscoring parents' efforts across the above identified categories and transitions.

All together, the findings of this study provide details of parents' motivations, knowledge, understandings, concerns, and ambiguities underscoring their efforts to prepare boys and girls for exploring and entering the STEM pipeline. Beyond providing insightful explanations of the parents' perspectives, this study shares invaluable understandings that may be put to further use by parents, educators, parent advocates, STEM researchers and policymakers, who are interested in the development of feasible strategies and forward leading opportunities for strengthening the STEM pipeline.

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Andrew C. Porter

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NUTS, BOLTS AND A BIT OF METTLE:
HOW PARENTS PREPARE THEIR BOYS AND GIRLS FOR THE
STEM PIPELINE

Rashmi Kumar
A DISSERTATION
in
Teaching, Learning, and Curriculum

Presented to the Faculties of the University of Pennsylvania
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Nuts, Bolts and a Bit of Mettle:
How Parents Prepare their Boys and Girls for the STEM Pipeline

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Rashmi Kumar
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To all the participants who shared their stories that made this study possible, I offer my heartfelt gratitude.

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This dissertation is a tribute to my grandmother who was able to attend school until fifth grade only, and then later, made unwavering efforts towards empowering her daughters and granddaughters to experience the joys and rewards of higher education.
ABSTRACT

NUTS, BOLTS AND A BIT OF METTLE: HOW PARENTS PREPARE THEIR BOYS AND GIRLS FOR THE STEM PIPELINE

Rashmi Kumar
Katherine Schultz, Ph.D.

The needs for strengthening the STEM pipeline in the United States have moved beyond routine concerns and acquired an unprecedented level of urgency. As a result, many educational and business entities, and government and private organizations have launched myriad initiatives targeted towards achievement of the above goal. The extant body of research, while certainly explicating the essential steps that can be actuated by educational, research, and legislative entities, has largely left out the potential role of parents. Accordingly, the primary question guiding this research was: How do parents prepare their boys and girls for the STEM pipeline? What is the range and variation of support given by fathers and mothers to their children for exploring and entering STEM fields?

Based on this study’s findings, I posit that parents extend support through a model of “AID: Adaptive, Incidental, and Deliberate Practices” representing the totality of their choices, decisions, perspectives, actions, and interventions. The study reveals parents’ efforts within an evolving pattern of noteworthy transitions, commencing from children’s early childhood years and lasting through high school. Finally, this study has identified a
unique combination of characteristics underscoring parents’ efforts across the above identified categories and transitions.

All together, the findings of this study provide details of parents’ motivations, knowledge, understandings, concerns, and ambiguities underscoring their efforts to prepare boys and girls for exploring and entering the STEM pipeline. Beyond providing insightful explanations of the parents’ perspectives, this study shares invaluable understandings that may be put to further use by parents, educators, parent advocates, STEM researchers and policymakers, who are interested in the development of feasible strategies and forward leading opportunities for strengthening the STEM pipeline.
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CHAPTER ONE: INTRODUCTION

All young Americans should be educated to be STEM-capable, no matter where they live, what educational path they pursue, or in which field they choose to work.

(Commission on Mathematics and Science Education, 2009, p. 2)

Problem Statement and Significance

In the past few decades, educational and occupational opportunities in science, technology, engineering, and mathematics (STEM) have experienced rapid growth in the United States as well as in many global regions (Commission on Mathematics and Science Education, 2009; National Science Board, 2002; National Science Foundation, 2004). In the United States, growth in participation levels within STEM fields has not paralleled the increase seen in the availability of opportunities (Hill, Corbett, & Rose, 2010; Jacobs & Simpkins, 2005). The presence of stark gaps between opportunity and accessibility is particularly evident among some ethnic, racial, and socio-economic groups (Hill, Corbett, & Rose, 2010; Jacobs & Simpkins, 2005; National Science Board, 2008).

The rapidly growing demands of economic, industrial and governmental organizations in the United States require a qualified workforce with skills and knowledge related to STEM fields (Commission on Mathematics and Science Education, 2009; Jacobs & Simpkins, 2005; President’s Council of Advisors on Science and Technology, 2010). More importantly, the benefits of pursuing the STEM pipeline are significantly higher at individual levels (Burke & Mattis, 2007; Osborne, Simon, &
Collins, 2003). Studies conducted by the American Association for the Advancement of Science, the National Science Foundation, and the National Science Teachers’ Association reveal that among the 20 fastest growing occupations projected for 2014, more than three-fourths will require high levels of preparation in STEM fields (American Association for Advancement of Science, 2006; National Science Foundation, 2000, 2006; National Science Teachers’ Association, 2002). For the reasons stated above, encouraging K-12 students to acquire skills, knowledge and dispositions associated with STEM fields is understood to be critical (American Association for Advancement of Science, 2006; National Science Foundation, 2006).

Extant research indicates that initiatives undertaken by K-12 schools, institutions of higher education, state and federal departments, and non-profit organizations have yielded positive results in encouraging and sustaining a broader participation of youth in the STEM pipeline; however, frequently, the outcomes have been of limited measure (e.g., Commission on Mathematics and Science Education, 2009; National Center for Education Statistics, 2008, 2009; National Science Foundation, 2004; President’s Council of Advisors on Science and Technology, 2010).

The past few years have witnessed well-known organizations emphasizing the importance of robust participation in the STEM pipeline (e.g., American Association for Advancement of Science, 2006; Commission on Mathematics and Science Education, 2009; National Science Foundation, 2008). Extant research has indicated that sustaining youth in the STEM pipeline is an ambitious and long-term undertaking that requires the collaborative efforts of educational, societal, and legislative institutions (e.g., American Association for Advancement of Science, 2006; National Science Foundation, 2000, 2006; Commission on Mathematics and Science Education, 2009; National Science Foundation, 2004; President’s Council of Advisors on Science and Technology, 2010).
Although the roles of K-12 schools, post-secondary institutions, and out-of-school organizations have been articulated, often, these recent reports have excluded the potential role of parents in broadening the STEM pipeline (American Association for Advancement of Science, 2006; Commission on Mathematics and Science Education, 2009; National Science Foundation, 2008).

The Elementary and Secondary Education Act passed in 1965 set the stage for legislative actions, which in time, brought attention to parents’ role in achieving the goals of K-12 education (Elementary and Secondary Education Act, 1965; Harvard Family Research Project, 2007). Since then, research studies on the importance of parent involvement\(^1\) on children’s academic progress have experienced steady growth, and resulted into some universal understandings among educators, researchers, and policy makers (e.g., Bouffard & Weiss, 2008; Epstein & Sheldon, 2006; Lareau, 2003; Pattillo, 2008; Ream & Palardy, 2008). Many of these understandings are in an ongoing state of adjustment and transformation.

Amidst the continuously evolving research findings, educators, researchers, and policy makers agree on one understanding: parent involvement is critical for enhancing children’s educational progress, and also helpful in overcoming the impact of any detrimental factors in children’s learning environments (Epstein, 2001; Epstein & Sanders, 2000; Fraja, Oliveria, & Zanchi; 2010, Lareau, 2003; Pattillo, 2008; Perry, Pryzybysz, & Al-Sheikh, 2009). Although family involvement is widely acknowledged as a pivotal factor responsible for promoting children’s academic success, surprisingly research on parents’ roles in strengthening the STEM pipeline is not well developed

\(^1\) Detailed information on parent involvement has been included in Chapter Two
 quite possibly, lack of a vast body of research regarding STEM education can be attributed to its nascent and emerging character.

The current gaps and inequities in the STEM pipeline have alarmed educators, policy makers, and business entities (American Association for Advancement in Science, 2006; Hill, Corbett, & Rose, 2010; Cleaves, 2005; Kuenzi, Matthews, & Mangan, 2006; Osborne, Simon, & Collins, 2003; National Center for Education Statistics, 2009). These apprehensions have created rippled effects, some of which have resulted into reconsideration and revision of existing policies and guidelines. Yet, the direness of the above situation has not abated. Within the concerns voiced by different groups of stakeholders, it becomes useful to focus attention on relatively unexplored areas of research. As mentioned previously, research on parent involvement specifically within STEM fields has remained largely unexplored.

Accordingly, this dissertation was directed towards unraveling and explicating the range and variation of support provided by parents whose children have inclinations towards STEM fields to enable their children for exploring and entering the STEM pipeline. The parents and children included in this study are affiliated with an out-of-school organization with an outstanding track record of providing STEM learning experiences for high school students. A clear majority of these students have already demonstrated significant levels of success in the STEM pipeline at the time this research study was conducted. It is in this context that the collective perspectives and attributions of parents and students are of critical value for understanding the underpinnings of these parents' efforts. This study was undertaken within the explicit understanding that the
research sample is likely associated with distinctive characteristics that may not be found elsewhere in the larger population under exactly similar circumstances and with comparable outcomes.

Research Questions

During the last four years at Perm GSE, I have acquired substantial knowledge about the importance of a robust STEM pipeline as well as the various processes through which parents support their children’s overall academic progress. Although I have found an extensive body of literature regarding the importance of parent support in children’s education, I have been unable to identify details regarding how parents provide support for their children to explore and enter the STEM pipeline. This dissertation aims to provide insights into currently missing links in STEM education by uncovering the range and variation of resources through which parents support their boys and girls to participate in STEM fields; and thereby, exploring parents’ potential roles in strengthening the STEM pipeline.

Based on the above stated considerations, the primary research question guiding this dissertation study is:

- How do parents support their boys and girls for participation in the STEM pipeline? What is the range and variation of support given by fathers and mothers to their children for exploring and entering STEM fields?

In addition to the primary question, I ask the following sub-questions:

- How does the support provided respectively by parents of boys and girls compare with each other? Is it possible to discern any differences within the actions of fathers and mothers? What kinds?
• How does parents' support vary by race, ethnicity, or social class? What are the commonalities in the support provided by parents from different backgrounds? What are the essential and recurring themes?

• What are the perceptions of boys and girls about parental support? What are the relationships between these views and those of their parents?

Personal Interest and Professional Background of the Researcher

This research study speaks to many personal interests and builds upon experiences gained through various commitments over the last several years. Before joining the Graduate School of Education at the University of Pennsylvania, I was a public school teacher. During my extended tenure as an elementary, middle, and high school teacher, and then, extending into my status as a doctoral student, I kept a journal to make note of ongoing thoughts and dilemmas. On several occasions, I have used the emerging questions to design small-scale research studies.

My educational background is deeply rooted in pure sciences and technology. During the last few years, I was deeply involved in disseminating information about emerging sciences and technologies among K-12 teachers. Later, these efforts became the foundations of a graduate course that I developed and taught at a state university. The underlying goal of the course was to expand teachers' readiness for facilitating STEM knowledge and skills among K-12 students. For several years, I have also worked with diverse groups of students and families, exploring ways to facilitate their active participation in school-based activities. Likewise, the inspiration for pursuing this dissertation study has developed from within my teaching practices and related professional experiences. My course studies, interactions with professors and peers, and
experiences gained from several conferences have further inspired me to conduct this research.

Three essential realizations have strengthened the resolve to conduct this research: 1) my combined experiences of working with fellow teachers and parent groups have had profound influence on my knowledge; 2) my dual status as a parent and university researcher has provided deeper understanding of the STEM pipeline; and 3) experiences gained from developing and probing hypotheses have been very meaningful. To that end, I see my professional and personal backgrounds as strong contributors to the strength, direction, and prospects of this study.

Prospective Value to the Field

The extant body of research, while certainly explicating how parental beliefs and expectations are instrumental for facilitating the academic progress of their children, provides lesser information about how parents’ efforts bear influence on children’s participation in the STEM pipeline (e.g., Bregman & Killen, 1999; Davis-Kean, 2005; Eccles, Davis-Kean & Simpkins, 2006; Jacobs & Simpkins, 2005; Kahle, 2004; Osborne, Simon, & Collins, 2003). Widely circulated reports such as those released by the Commission on Mathematics and Science Education (2009) and the President’s Council of Advisors on Science and Technology (2010), explicate the potential roles of governmental, private, and industrial institutions in expanding the STEM pipeline; however, they do not make explicit mention of parents’ roles in supporting boys and girls to become successful entrants in the STEM pipeline.
The findings of this dissertation have significance because they add to extant
literature by identifying and describing resources utilized by parents to support their
children's participation in the STEM pipeline. The findings from this research will
provide educators and policy makers, and non-governmental and community
organizations, a close look at how parents make contributions towards increasing the
participation of youth in STEM fields. In turn, these groups and organizations may be
able to use the insights emerging from this study to provide a structure of assistance for
parents in critically identified areas.

There are two other factors that make this research study important. First, current
literature indicates that parents support their children's learning within "intricate
educational, societal, and cultural contexts" (e.g., Harvard Family Research Project,
2008, p. 6). By conducting this research among a group of fathers and mothers of boys
and girl from diverse backgrounds, the findings allow for broader and more viable
conclusions. Second, several research studies reveal that parents' expectations and
beliefs regarding boys and girls are of discrepant nature among fathers and mothers (e.g.,
Bleeker & Jacobs, 2004; Eccles et al., 1999; Francis & Skelton, 2005; Gurian, 2004;
Jacobs & Eccles, 1992; Lee, 2002; Lytton and Romney, 1991; Osborne, Simon, &
Collins, 2003; Parke, 2002; Puusitinen, et al., 2008). It is likely that these differences
impact adolescents' success in the STEM pipeline. The knowledge about gender
differences and family support has witnessed steady growth over the past several
decades; however, the differences regarding support provided respectively by fathers and
mothers to boys and girls for pursuing the STEM pipeline have not been explored
extensively (Bleeker & Jacobs, 2004; Fraja, Oliveria, & Zanchi, 2010; Gurion, 2004; Jacobs & Simpkins, 2005).

To summarize, this study attempts to close some gaps in current literature. By elucidating details regarding the range and variation through which parents support their children to pursue opportunities in the STEM pipeline, I feel confident that the proposed study will add to the extant literature. The insights gained from this study may be able to provide a compilation of purposeful and transferable practices that can be used by a larger audience. I believe its findings are of timely interest to parents and youth on the one hand, and educators, parent advocates, and education policy makers on the other.

Organization of the Thesis

This dissertation is organized across seven chapters including this introductory one. Chapter two provides a detailed overview of two fields: the foundations of the STEM pipeline and the dynamics of parent involvement. This is followed by chapter three detailing the research methods guiding this dissertation. Chapters four through six provide analyses of the research findings in the form of thematic groupings. Chapter four focuses on the skills fostered by parents in order to strengthen children’s readiness for the STEM pipeline. Following this, chapter five explores the unconventional and exceptional strategies, resources, and social networks used by these parents. Next, chapter six discusses the complexities of parents’ decisions as they evaluate choices and possible outcomes as well as the underlying assumptions informing their decisions. Each chapter, from four to six, begins with an overview of extant literature related to the specific theme, and also its connections with the broader fields of literature outlined in...
chapter two. In closing, chapter seven offers a critical analysis of the findings in chapters four, five, and six, followed by discussion of an emergent and essential model representing the parents' efforts, understandings, and decisions as well as the noteworthy transitions seen within the emphases of parents' efforts. This is followed by implications of this study's findings on current policies, guidelines, and initiatives for realizing a robust STEM pipeline, and closes with possible directions for further research studies.
CHAPTER TWO: LITERATURE REVIEW

Introduction

The questions that I have investigated in this research are informed by a confluence of two fields of literature; each has been developed through different antecedents and undergirded by unique perspectives. Accordingly, the literature review is divided into two parts: the STEM pipeline and parent involvement. Part one begins with a characterization of the STEM pipeline including key terminology used frequently in literature. Next, I offer an overview of current dynamics of the STEM pipeline and the motivations underscoring the urgency for broadening the STEM pipeline. This is followed a discussion of the individual, societal, and economic advantages of a robust STEM pipeline, and then, the characteristics frequently associated with success in STEM fields. The purpose was to provide a theoretical background of the relationships between historical aspects of boys’ and girls’ academic achievements and the role of personal beliefs in the context of the STEM pipeline’s current status. In closing, this section reviews research on the broader impact of a ‘shrinking’ STEM pipeline in the United States (Jacobs, 2005).

Similarly, part two of the literature review starts with descriptions of frequently used terminology and key concepts within current research regarding parental support. Next, I describe the parent support across differences of cultural, racial/ethnic, educational, and economic characteristics and the interrelationships among and between the different attributes. This is followed by an analytical review of varied constructs through which mothers and fathers provide support for their boys and girls. In closing, I
review some common critiques against dominant theoretical frameworks as well as some emerging areas of consensus in the field.

Part I: The STEM Pipeline

Making Sense of the Terminology

During the past few decades, and particularly, within the last five years, STEM fields and the STEM pipeline have been at the forefront of many public discourses and dominated the agenda of many educational organizations in the United States (American Association for Advancement in Science, 2006; Committee on Science, Engineering, and Public Policy, 2011; Hill, Corbett, & Rose, 2010; Kuenzi, Matthews, & Mangan, 2006; National Center for Education Statistics, 2009). Additionally, educators, research organizations, and policy makers, have advocated that citizens take active participation in the ongoing discussions (Commission on Mathematics and Science Education, 2009; Eccles, Davis-Kean & Simpkins, 2006; Hill, Corbett, & Rose, 2010; National Science Board, 2008). The large scale and concerted attempts to extend the dialogues among larger numbers of people are seen as important indicators of this subject’s growing significance (Commission on Mathematics and Science Education, 2009).

Like many vigorous deliberations where some key terms assume central position to the exchange of ideas, discussions focused on the STEM pipeline are no exception. However, it is often also commonly seen that whenever conversations intensify over a lengthy period of time, the interpretative meanings assigned to the different terms undergo modifications (Green, 2007; Kuenzi, Matthews, & Mangan, 2006). In order to
situate this study within a current framework of commonly terminology, it becomes worthwhile to contextualize the terms, and also to identify the specific ones used in this thesis.

**STEM Fields**

For a considerable period of time, organizations such as the National Science Foundation included a broad range of subjects including mathematics, natural sciences, engineering, computer and information sciences along with social/behavioral sciences such as economics, psychology, and political science under the term ‘STEM fields’ (Green, 2007; National Center for Education Statistics, 2009). However, in response to challenges in specific fields of study, many federal and state initiatives have now chosen to confine the usage of STEM to identify science (including natural and physical sciences), technology, engineering and some categories of mathematics\(^2\) (Hill, Corbett, & Rose, 2010; Kuenzi, Matthews, and Mangan, 2006; National Center for Education Statistics, 2009). This dissertation follows similar rules of nomenclature, and therefore, includes only pure sciences (biological and physical), computer and information technologies, all categories of engineering, and applied mathematics, and excludes all social/behavioral sciences from STEM (Kuenzi, Matthews, and Mangan, 2006; National Center for Education Statistics, 2009).

\(^2\) See the technical notes section from National Center for Education Statistics, 2009
The STEM pipeline has become a universal metaphor that recognizes the “path from elementary school to a STEM career” (Hill, Corbett, & Rose, 2010, p. 17; see also Commission on Mathematics and Science Education, 2009). Accordingly, the STEM pipeline includes all points of entry across a wide range of educational and vocational choices within individual advancement towards established careers in STEM fields (Jacobs & Simpkins, 2005; National Center for Education Statistics, 2009).

Until a few years ago, the United States had occupied an envious position as the global leader of innovation and scientific breakthroughs enabled by a strong STEM pipeline. That is not the case anymore now; the STEM pipeline in the United States has experienced significant decline caused by a reduction in the numbers of people completing the necessary trajectory (Hill, Corbett, & Rose, 2010; Jacobs & Simpkins, 2005). The attritions and declines in the STEM pipeline are often referred to as the “leaks in the STEM pipeline” (Jacobs & Simpkins, 2005, p. 3). In the United States, two key factors have escalated the manifestation of leaks in the STEM pipeline—1) overall decline in the percentages of students who complete post-secondary education, and 2) rapid decreases in the total numbers of students who matriculate into STEM undergraduate degrees (Hill, Corbett, & Rose, 2010). The significance of these concerns will be discussed in detail a little ahead in this literature review.
STEM Entrants

All individuals who enter the STEM pipeline at any given time are considered as "STEM entrants" (National Center for Education Statistics, 2009, p. 2) versus those who do not participate at all in the STEM pipeline (National Center for Education Statistics, 2009). The Statistics Brief released by National Center for Education Statistics (2009) uses a narrow time frame during which entry into the STEM pipeline is considered meaningful and also worthy of inclusion in related statistical data:

To identify students entering STEM fields, this Statistics Brief...considers anyone a STEM entrant if that student has reported a major (first or second major if that information is available) in a STEM field at any time during his or her post-secondary enrollment. This definition attempts to capture all students who enter STEM fields, including early entrants, later entrants, those who change changed majors, and those with a second major in a STEM field (National Center for Education Statistics, 2009, p. 2)

However, some recent reports released by the American Association of University Women and the National Science Foundation, posit that all students who study any or all STEM fields during elementary, middle, and high schools and post-secondary institutions should be considered as STEM entrants (Hill, Corbett, & Rose, 2010; National Science Foundation, 2009). In a slightly modified interpretation, Jacobs & Simpkins (2005) view all individuals who pursue STEM fields starting from elementary school onwards to beyond post-secondary years as STEM participants. In this dissertation, individuals who enter the STEM pipeline by following the National Center for Education Statistics (2009) guidelines will be identified as STEM entrants, and those who do not as "non-STEM entrants" (National Center for Education Statistics, 2009, p. 2; see also Committee on Science, Engineering, and Public Policy, 2011; Jacobs & Simpkins, 2005).

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3 Detailed guidelines of classifying STEM entrants and non-STEM entrants are available in the report released by National Center for Education Statistics (2009).
In similar manner, extant literature also reveals existence of several phraseologies describing the STEM workforce. Several research studies and meta-analyses focusing on the development of the STEM workforce have used fluid explanations—with some occupations being included or excluded depending on the motivations and/or goals of authors or the sponsoring organizations (e.g., National Science Board, 2010; National Science Foundation, 2007; U.S. Department of Labor, 2007). The most commonly utilized and straightforward approach is to include all those people whose occupations are recognized as any one of the individual STEM fields (U.S. Department of Labor, 2007). However, this approach fails to identify occupations requiring STEM skills in primarily non-STEM fields such as management, law, business, and construction (National Science Foundation, 2007). Another example of variations in terminology and ensuing ambiguities can be seen in the exclusion of K-12 STEM teachers, and yet, inclusion of higher education faculty specializing in STEM content (Commission on Mathematics and Science Education, 2009).

The Science and Engineering Workforce report prepared by the National Science Foundation (2007) offers a more inclusive model that can be adapted for defining the STEM workforce:

In this definition, a precollege teacher with a baccalaureate or the equivalent in a field of science, mathematics or engineering is a member of the science and engineering workforce. Also included are practitioners with two-year degrees and certificates in science, engineering and technology fields. Further, doctoral level scientists in postdoctoral positions form a vital and growing component of the US S & E workforce in some fields of research, notably nowadays in biomedicine (vi).
Still others include one or more fields from among science, technology, engineering, and mathematics but not all (e.g., National Science Board, 2008, 2010, U.S Department of Labor, 2007). However, this dissertation study includes participants from all four fields—science, technology, engineering, and mathematics within its considerations and findings. The above approach for classifying members of the STEM workforce has been used in this study because it provides a pragmatic framing and “appears to be more in keeping with how degree holders view themselves” (National Science Foundation, 2007, vi).

Characterization of the STEM Pipeline

The growing demands of increasing numbers of economic, industrial and governmental entities require a steady inflow of workforce equipped with STEM skills and knowledge (Jacobs & Simpkins, 2005; National Science Board, 2010; National Science Foundation, 2008). For the last several decades, the United States has been considered as the global leader in creating technological and scientific innovations (Jacobs & Simpkins, 2005). This distinguished status was enabled to a great extent by a robust pipeline of scientists, engineers, and researchers demonstrating well developed STEM skills and knowledge (Commission on Mathematics and Science Education, 2009). The dynamics have changed; now, people trained in STEM fields are essential for a broader range of industries and professions (Jacobs & Simpkins, 2005; Lacey & Wright, 2009; National Science Board, 2010).

Research conducted by the American Association for the Advancement of Science (2006) reveals that by 2014, out of the projected 20 fastest growing occupations,
will require high levels of preparation in STEM. The above findings are consistent with workforce projection studies conducted by U.S. Department of Labor which reveal that—“nine out of the ten fastest growing occupations that require at least a bachelor’s degree will require significant scientific or mathematical training” (U.S. Department of Labor, Bureau of Labor Statistics, 2009, p. 4). “Over the coming decades, today’s young people will depend on the skills and knowledge developed from learning math and science to analyze problems, imagine solutions, and bring productive new ideas into being” (Commission on Mathematics and Science Education, 2009, p. 1).

Discounting minor differences, there is agreement among many prominent organizations that STEM jobs are very likely to grow faster than the average rate of all other occupations (e.g., National Science Board, 2010; U.S. Department of Labor, Bureau of Labor Statistics, 2009). Additionally, the largest increases are expected within engineering, physical sciences, and information technologies, which bring us to an interesting nexus because they are also the fields facing the highest degree of challenges in recruiting and retaining youth (Eccles, 2006; Lacey & Wright, 2009; National Science Board, 2010; U.S. Department of Labor, Bureau of Labor Statistics, 2009).

National Science Foundation, the leading research organization in the United States on matters of progress in STEM fields, estimates that about five million people work in STEM related fields (Hill, Corbett, & Rose, 2010; National Science Board, 2010). Though this number may appear to be impressive, it comprises only four percent of the national workforce (National Science Board, 2010). Information regarding the numbers/percentages of college freshmen who declare their intent to major in STEM degrees is perceived as an important indicator of the future strength of the STEM pipeline
(National Science Board, 2008). The “2008 Digest of Key Science and Engineering Indicators” published by the National Science Board includes statistical data relevant to understanding of current dynamics:

The social sciences and the biological/agricultural science are currently the most popular majors among those freshmen who identify a major at the time of entering college. The share of entering freshmen intending to major in computer sciences increased significantly from 1993 to 2000 and then declined sharply from 2001 to 2005.
(National Science Board, 2008, p.12)

Why has the need to create an expanded STEM pipeline become so important? Why now? The next section offers an overview of the urgency, as well as defines the opportunities and challenges in front of the US workforce.

The Importance of a Robust STEM Pipeline

Successful pursuit of the STEM pipeline is considered as an individual and public good and a prerequisite for an economy. It is understood that the national economy is strengthened through the efforts of individual citizens and organized groups who are prepared to solve problems and create innovations (National Science Board, 2008, 2010). Further, it is presumed that a strong STEM pipeline is capable of ushering in these positive results. Therefore, expansion of the STEM workforce is crucial for sustaining level of innovation and research (National Science Board, 2008).
Economic and Societal Benefits

The acquisition and application of STEM related knowledge, skills, and dispositions have been long considered as the forces, driving economic growth, national security, and individual prosperity (National Science Foundation, 2007). Starting from the Industrial Revolution in 18th century, continuous improvements impacting daily lives of all citizens have been made in medicine, manufacturing, communication, construction and mass infrastructure. As result, it is widely accepted that progress in STEM fields has contributed to the success and well-being of individuals and countries in developed as well as developing regions (Burke & Mattis, 2007; Congressional Commission on the Advancement of Women and Minorities in Science, 2000). This is particularly true in the United States, where the largest number of people have experienced high living standards as a result of advancements made in STEM fields (Burke & Mattis, 2007; Eccles, 2005).

Research organizations and government agencies are not alone in advocating for a robust STEM pipeline. Over 90% Americans agree that expansion in STEM fields will be able to provide more and improved opportunities for the next generation (The National Data Program for the Sciences, 2006). Furthermore, the General Social Survey of 2006 indicates that Americans who agree with the above assumptions have increased steadily at a moderate rate during last decade (The National Data Program for the Sciences, 2006). The above findings are corroborated by the Commission on Mathematics and Science Education (2009) which states that United States’ capacity to innovate is dependent on individuals’ “broad foundation of math and science learning” (p. 1; see also Burke & Mattis, 2007).
Global Trends and Numbers

According to the National Science Board (2008) growth in the STEM workforce is dependent on three factors: 1) degrees in STEM earned by native and foreign born students, 2) temporary and permanent migration of STEM educated individuals from other countries, and 3) numbers of STEM professionals who are ready to retire.

The 21st century, has witnessed simultaneous global economic prosperity in many parts of the world, and has escalated demand for innovative services and products. In highly industrialized nations, the increased emphases on developing economic, business and industrial establishments are echoing into proportionately higher demands for a workforce with STEM skills and knowledge. This includes countries, which up until now, were primarily focused on agriculture and basic industries, have witnessed sudden and urgent needs to recruit and retain employees who are proficient in STEM skills and knowledge (Burke & Mattis, 2007; Jacobs & Simpkins, 2005; National Science Foundation, 2000, 2009). Subsequently, many parts of the world which were lagging so far are experiencing unprecedented demand for STEM talent (Burke & Mattis, 2007). As a result “the emerging global marketplace is making the [above] characteristics even more important, as shifts in the labor market indicate clearly” (Commission on Mathematics and Science Education, 2009, p. 10).

Unlike the trends witnessed in the previous century when foreign born STEM talent was drawn to the United States in large numbers, the global demand for skilled STEM workforce has provided multitudes of opportunities in other parts of the world. This decade has particularly witnessed many countries expanding internal outreach towards development of STEM education and offering graduates better incentives to stay
Because of the cumulative changes elsewhere in the world, the numbers of foreign nationals with STEM degrees or intentions to pursue higher education in STEM fields, and who, previously, made up for the shortfall in internal US numbers have been decreasing steadily (National Science Foundation, 2000, 2009). Although some people that the US remains an attractive destination for foreign nationals with STEM backgrounds, the precipitous drop in the total numbers is of real concern, causing anxiety among many (Jacobs & Simpkins, 2005). “The supply of foreign students is likely to diminish as they find increased opportunity in their home countries, rising U.S. tuition, competition for students from other countries, and difficulties in obtaining U.S. visas” (Sevo, 2009, p. 1).

Based on longitudinal studies conducted by Jacobs & Simpkins (2005); the National Science Foundation (2000, 2009), and Pell (2004), it can be surmised that fewer international students are opting to study STEM fields in American universities, which is also evidenced within the declining numbers of applications from foreign candidates. More frequently than has been ever witnessed previously, international students from countries such as India, China, and South Korea are returning to their native homelands after pursuing higher education in the US (Pell, 2004). However, since this is a relatively new phenomenon, there is a lack of sufficient statistical data to qualify the changes (National Science Board, 2008).

In lieu of absolute and measurable data, for the time being, supplementary indicators are being used to validate emerging dynamics (National Science Board, 2008). For example, it is understood that “publication of research in the form of articles in peer-reviewed journals indicate contribution to the knowledge bases” (National Science
Board, 2008, p. 13), and can be used as reliable proxy measure the robustness of innovation and advancement in STEM fields (Jacobs, 2005). The Physical Review Journal, a key publication of the American Physical Society has seen dramatic changes in its publication trends—since 2004, more non-Americans than Americans publish their research in the journal; a growing number of non-Americans publishing their research in this journal are affiliated with foreign universities (Broad, 2004).

The participation of US citizens and green card holders (citizens of other nations with legal status in the US) in STEM fields is closely related to total attainment of postsecondary education in the US. Until 1994, the United States ranked second internationally in the percentages of people completing college degrees; by 2006, the relative position had slid to number five (Commission on Mathematics and Science Education, 2009). Although the absolute percentages of college educated citizens in the US have remained steady, the percentages in countries such as New Zealand, Finland, and Japan have increased rapidly (Cleaves, 2005; Commission on Mathematics and Science Education, 2009; Jacobs, 2005; Jacobs & Simpkins, 2005). Just in the recent past, China and India have made headline news regarding the internally improved conditions of education and numbers of STEM graduates, causing confusion as well as consternation inside educational and business circles in the United States (Broad, 2004; Pell, 2004; Sevo, 2009). In order to settle resultant ambiguities, it is important to point out that China and India remain far below the United States in percentages of college-educated adults. However, their absolute numbers are growing far rapidly, mostly because of the large sized populations and changes in local economic conditions (Broad, 2004; Pell, 2004).
The Substantive Benefits at the Individual Level

The advantages of STEM education are not limited to societal and economic fronts; benefits of pursuing the STEM pipeline increase substantively at individual levels (Cleaves, 2005; Jacobs, 2005; Jacobs & Simpkins, 2005). For instance, the Bureau of Labor Statistics\(^4\) (2007) projects that 54.7 million jobs will become available during the period between 2004 and 2014, out of which 29.4 million (more than 50%) will require a college degree; among these, employment opportunities in STEM occupations are projected to grow at higher rates than those in non-STEM fields (National Science Board, 2008). More recently, the emphasis on increasing STEM skills and knowledge of youth has been further escalated: National Research Council’s 2007 report, *Taking Science to School* posits that regardless of their educational or vocational choices, all young citizens should be ready for “knowing, using, and interpreting scientific explanations” (p. 2).

STEM fields have good track records of providing personal growth and positive career changes (National Association of Colleges and Employers, 2009):

**The only job categories for which both demand and wages are continuing to grow are non-routine analytic positions, requiring, both good judgment, and an ability to solve problems, and strong communication, information management and synthesizing skills.**

(Commission on Mathematics and Science Education, 2009, p.10)

Individuals entering STEM fields also enjoy better job security than others (National Association of Colleges and Employers, 2009). In a jointly commissioned study, the Carnegie Corporation and the Institute for Advanced Study have claimed that during

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\(^4\) Clear data regarding the changes that are resultant of the recent economic downturn in the United States is not available (Bureau of Labor Statistics, 2009); however, as documented in the report by the Commission on Mathematics and Science Education (2009), the outlook for STEM occupations is better than for non-STEM ones
weakened conditions of the US economy, opportunities in STEM fields provide relatively safer havens for new graduates (Commission on Mathematics and Science Education, 2009).

Pursuit of STEM careers education and careers is often portrayed as an issue of pay equity (Eccles, 2005; Hill, Corbett, & Rose, 2010; Jacobs, 2005). In general, people with bachelor’s degrees in STEM majors receive the highest starting salaries and accrue faster job promotions than non-STEM majors (National Association of Colleges and Employers, 2009). For instance, in 2009, the average starting salary for a person with a bachelor’s degree in mechanical engineering was in vicinity of $59,000 and $61,000 in computer sciences, whereas the average starting salary for a person with a bachelor’s degree in economics was under $50,000, and further less in other social sciences (Hill, Corbett, & Rose, 2010; National Association of Colleges and Employers, 2009). More importantly, after six years of enrollment in post-secondary institutions, majority of STEM entrants fared better than non-STEM entrants (National Center of Education Statistics, 2009).

Lastly, participation in STEM fields has also been associated with higher levels of job satisfaction and self-esteem (National Association of Colleges and Employers, 2009; National Science Board, 2008). It has been found that generally speaking, all Americans, including young and old, Black and White, men and women, display high esteem for scientists and their potential contributions towards the societal good (National Science Board, 2008). However, the primary reasons for job satisfaction in STEM fields are not monetary; instead, are closely related to aspects of finding solutions for societal problems (Hill, Corbett, & Rose, 2010; National Science Board, 2008, 2010). Evidence of higher
esteem of STEM fields are also seen within mass media, such as representations of scientists and engineers "working to solve some of the most vexing challenges of our time—finding cures for diseases like cancer and malaria...providing [all] people with clean water" (Hill, Corbett, & Rose, 2010, p. 3).

Data on public esteem for [STEM] occupations may be an indicator of the attractiveness of these occupations and their ability to recruit talented people into their rank...Some evidence suggests that Americans rate scientific careers more positively than is the case in at least some other countries. (National Science Board, 2008, Executive summary, p. 4)

For the last 30 years, the Harris Poll has been collecting data about relative prestige of large range of occupations—in the 2006 poll—over 50% Americans indicate that scientists hold positions of high prestige, and over 34% indicate the same for engineers (Harris Interactive, 2006; National Science Board, 2008).

In 2004, a little over 50% of South Koreans said they would feel happy if their son or daughter wanted to become a scientist but 80% of Americans surveyed in 2001 expressed this feeling. (National Science Board, 2008, Executive summary, p. 4)

The above information leads to some rather interesting predicaments. As such, comparisons of parental perceptions in the US and South Korea would be indicative of higher numbers of girls and boys in the United States pursuing opportunities towards becoming scientists or engineers, but it is not (Harris Interactive, 2006). Furthermore, current trends demonstrate a stark contradiction because rates of attrition from the STEM pipeline both among boys and girls are significantly higher in United States than in South Korea (Harris Interactive, 2006; National Science Board, 2008).
Concerns about Leaks in the STEM Pipeline

Though educators and policy makers identify an imperative need to prepare students for working in an increasingly STEM driven economy, in actuality, the reverse trend is gaining traction in the United States (American Association for the Advancement of Science, 2006; Hill, Corbett, & Rose, 2010; National Center for Educational Statistics, 2003). The numbers and percentages of students pursuing degrees and careers in STEM fields have been steadily decreasing in the United States (American Association for the Advancement of Science, 2006). Although this is not a sudden or recent occurrence, the impact is more severe now because global migration of STEM professionals is experiencing dramatic shifts (National Science Foundation, 2006). Contrary to expectations, allocation of extra monies towards recruitment and retention of more students within STEM has not resulted into meaningful changes (Jacobs, 2005; Jacobs & Simpkins, 2005). Similar conclusions regarding schisms between escalated demands of the economy and increasingly reduced availability of people with STEM skills and knowledge have been drawn by the National Center for Educational Research (2007).

In the face of changing economic conditions in US, research organizations as well as legislative bodies are calling for a strengthened STEM pipeline. The Commission on Science and Mathematics (2009), views the imminent need to prepare youth for higher levels of achievement in science and mathematics as an “opportunity equation” (Executive Summary). The notion of an opportunity equation implies that all schools and post-secondary institutions need work towards meeting needs of a growing economy by developing a suitably prepared workforce (Commission on Science and Mathematics, 2009).
Our nation needs an educated young citizenry with the capacity to contribute to and gain from the country’s future productivity, understand policy choices, and participate in building a sustainable future. Knowledge and skills from...STEM fields are crucial to virtually every endeavor of individual and community life. (Commission on Science and Mathematics, 2009, p. 2)

It has become apparent that preparing today’s youth for becoming a sustained member of the STEM workforce has become a matter of grave concern for the government, educators and industrial establishments (Commission on Mathematics and Science Education, 2009; Lacey & Wright, 2009; National Science Board, 2010).

Understanding the Cause and Effect Relationships

Historically, women and members of some minority groups have been underrepresented in STEM educational and occupational tracks (Katehi, Peterson, & Feder, 2009; Lucena, 2000; Sevo, 2009; Williams, 2000). Many research studies exploring the current dynamics of STEM fields indicate that a critically missing component within the STEM pipeline is the equitable participation of females and students from diverse backgrounds (e.g., Kahle, 2004; Committee on Science, Engineering, and Public Policy, 2011; National Center for Education Statistics, 2001, 2008. 2009; National Science Foundation, 2004; Zeldin, Britner, & Pajares, 2008). Additional studies have demonstrated that in spite of recent spurts of progress, these two groups continue to face challenges within the STEM pipeline—both at the secondary and post-secondary institutions of education, and also, in professional opportunities (e.g., Burke & Mattis, 2007; Eccles, 2005; Jacobs, 2005; Vogt, Hocevar, & Hagedorn, 2007; Zeldin, Britner, & Pajares, 2008).
Despite the vigorous attempts of several federal and private organizations to increase recruitment of underrepresented groups in the STEM pipeline, the results have not been particularly impressive. The current status of the United States regarding its ‘inability’ to develop a strong workforce in STEM, the reduced participation of students, and stark comparisons in participation across gender and social class, together, have led to broad-based concern (National Center for Education Statistics, 2001; National Science Foundation, 2004).

**Issues of Gender Inequity in STEM**

The gender gaps manifest much earlier in STEM educational pathways and achievement levels than in the workplace (Muller, Stage, & Kinzie, 2001). In spite of strikingly similar levels of achievement in science and mathematics, differences in attitudes among boys and girls start surfacing during elementary years and continue into middle school years, and then, become exacerbated during high school years (American Association for the Advancement of Science, 2006; Burke & Mattis, 2007; Eccles, 2005; Else-Quest, Hyde, & Linn, 2010; Muller, Stage, & Kinzie, 2001; University of Michigan, 2007).

It has been found that during the middle school years, the differences in achievement, attitudes, and motivation across genders are rather minor in nature; however, they get intensified during high school years (Zeldin, Britner, & Pajares, 2008). Research indicates that dramatic shifts take place among both boys and girls during grades 9-12, when students start withdrawing from their previously expressed intentions (e.g., Burke & Mattis, 2005; Clewell, Anderson, & Thorpe, 1992; Leonardi, Syngollitou
& Kiosseoglou, 1998; Zeldin, Britner, & Pajares, 2008). The dropout rates among females are particularly disconcerting—not only do females demonstrate attrition from the STEM pipeline relatively sooner in comparison to males—their dropout rates are disproportionately higher than males (Burke & Mattis, 2005). During late high school and early post-secondary years, gender differences in the STEM pipeline are markedly noticeable; climaxing at age seventeen, without demonstrating meaningful drop in subsequent years (Drew, 1996; Muller, Stage, & Kinzie, 2001).

During high school years, boys outscore girls by small margins in high-stakes math assessments such as SAT and ACT and fewer girls take Advanced Placement courses in calculus, chemistry, computer sciences and physics (Halpern et al., 2007). Among girls who take AP tests in math, physics, computer science or chemistry, fewer obtain higher scores than boys (Halpern et al., 2007). However, very recently, the above findings have been strongly disputed by some researchers (e.g., Else-Quest, Hyde, & Linn, 2010). Instead, Else-Quest, Hyde, & Linn (2010) posit that girls have leveled with boys on their performance in math intensive subjects and demonstrate achievements at par.

Public recognition of growth in numbers and percentages of women obtaining bachelor’s degrees in STEM fields between 1966 and 2009 has been encouraging to researchers and policy makers alike (Hill, Corbett, & Rose, 2010; National Center for Education Statistics, 2009). But they also agree that growth has been short of satisfactory targets (National Center for Education Statistics, 2009; Zeldin, Britner, & Pajares, 2008). Unfortunately, disparities seen between men and women in the STEM pipeline continue to exist, in spite of many recent advancements; many of which, logically, should have led
to diminishing of differences (National Center for Education Statistics, 2009). For example, mathematics, often considered as a dominant gate-keeper for success in STEM fields, has witnessed major improvements, both within females’ levels of participation and performance (Else-Quest, Hyde, & Linn, 2010; National Center for Education Statistics, 2009; Spelke, 2005). According to a recent report released by the American Association of University Women, thirty years ago, the ratio of boys and girls scoring above 700 on the math component of SAT was 13 to 1; by 2009, the gap has reduced dramatically, now standing at 3 to 1 (Hill, Corbett, & Rose, 2010). Yet, these changes have not been able to translate into meaningful change. Further, Spelke (2005) posits that leaps made by females in “the most meaningful measure—the ability to master new, and challenging mathematical material” (p. 955) have not been successful in leveling off disparities in measurable ways.

From schools to colleges

The intended major of college freshmen in any particular field of study is a “leading indicator of the relative numbers of bachelor’s degrees” (National Science Foundation, 2008, p. 12). Based on extant research, it becomes apparent that beyond high school years, the STEM pipeline keeps contracting further (e.g., Spelke, 2005). Among all freshmen planning to matriculate into post-secondary degrees, only 15 percent of females versus 30 percent of males declare intentions of majoring in STEM fields (Hill, Corbett, & Rose, 2010; National Science Foundation, 2009; Spelke, 2005). The differences become more conspicuous if biological sciences are excluded because compared to 20 percent of males undergraduates who pursue non-biological/social
On the one hand, it is fortunate that recent studies indicate that girls have caught up with boys in their mathematical achievements; on the other hand, it is discouraging that we still continue to witness stark gender-based discrepancies within STEM fields (Else-Quest, Hyde, & Linn; 2010; Society for Research in Child Development, 2008; Spelke, 2005; University of Wisconsin-Madison, 2008). However, it is noteworthy that both genders are indicative of low rates of retention in STEM; among women, the reduced rates of retention are more pronounced because of meager initial numbers (Hill, Corbett, & Rose, 2009; Katehi, Peterson, & Feder, 2009; National Center for Education Statistics, 2009). The following data set summarizes the gaps seen recently within women’s participation in STEM fields:

Women earned 48,001 biological science degrees in 2007, compared with only 7,944 computer science degrees, 2,109 electrical engineering degrees, and 1024 physics degrees. In comparison, men earned 31,347 biological science degrees, 34,652 computer science degrees, 16,438 electrical engineering degrees, and 3,846 physics degrees. (National Science Foundation, 2009, p. 14)

The above indicates that in 2007, women earned majority of bachelor’s degrees in biology, one half in chemistry, and nearly one-half in math (National Science Foundation, 2009; see also Hill, Corbett, & Rose, 2009; Katehi, Peterson, & Feder, 2009). Far fewer degrees are earned by women in physics, engineering, and computer sciences—in fact, women’s participation in computer sciences stands at a low 20 percent (Hill, Corbett, & Rose, 2009; see also Katehi, Peterson, & Feder, 2009). Considering that after climbing to 36 percent participation levels during the mid-1980s, it is rather
unfortunate, women’s current participation in computer sciences has receded to levels seen in the early 1970s (Katehi, Peterson, & Feder, 2009; National Science Foundation, 2009). Similar conclusions can be extrapolated regarding women’s completion of doctoral degrees in STEM fields—women earn more than half of doctoral degrees in biological and agricultural sciences, and yet, only, one fifth of doctorates in computer sciences and engineering (Hill, Corbett, & Rose, 2010; Katehi, Peterson, & Feder, 2009; National Science Foundation, 2009; University of Wisconsin-Madison, 2008).

The Transfer of Gender Differences into the Workforce

The representation of women in STEM occupational fields continues to be consistent with trends established during their educational progress (Hill, Corbett, & Rose, 2010). The Department of Labor, which first began collecting data pertaining to occupational choices in 1960, since then, has documented an increase from 27 percent to 44 percent in women’s professional presence in biological fields. During the same time, women engineers have increased from one percent to 11 percent. Though these numbers are indicative of statistically significant growth, these are not demonstrative of sufficient progress because of extremely low numerical participation (U.S. Department of Labor, Bureau of Labor Statistics, 2009).

Similar kinds of asymmetries can also be witnessed among women of different age groups—among those with advanced degrees—and also within jobs related to biological sciences (U.S. Department of Labor, Bureau of Labor Statistics, 2009). As a result, it is likely that men occupy positions of influence at workplaces in greater numbers (U.S. Department of Labor, Bureau of Labor Statistics, 2009).
Another factor that contributes to the disparities between men and women in the STEM workforce is entrenched in women’s relatively higher rates of attrition from STEM occupations (Ceci & Williams, 2007; Hewlett, et al., 2008). Historically, attrition from STEM fields among females has been most harshly felt within engineering (Marra et al., 2007). Furthermore, attrition rates of women from STEM fields are higher than the attrition rates of women from non-STEM fields (Ceci & Williams, 2007; Halpern et al., 2007; Hewlett, et al., 2008; National Association of Colleges and Employers, 2009).

It is clear that women are underrepresented within most STEM fields except in biological and agricultural sciences; however, some other researchers have proposed strikingly disparate views (e.g., Lorber, 2001; Lucena, 2000; Mullis et al., 2000; National Center for Education Statistics, 2009; National Science Foundation, 2009). Some researchers assert that underrepresentation of women in STEM fields is a manifestation of personal choices and motivations rather than one of opportunities or the lack of adequate support (e.g., Mullis et al., 2000). Still some others attribute the inconsistencies seen within STEM participation to biological characteristics of boys and girls which in turn result into gender based differences in aptitudes and abilities (e.g., Ceci & Williams, 2007; Lorber, 2001; Lucena, 2000).

*Female Achievement and Self-Concepts regarding Success in STEM*

Math, computer technology, and physical sciences are often associated with males, and likewise, humanities and biological sciences with females, thereby, leading to commonly held conceptualizations of ‘masculine’ and ‘non-masculine’ fields (Ceci & Williams, 2007; Halpern et al., 2007; Hill, Corbett, & Rose, 2010; Katehi, Peterson, &
Feder, 2009; Lundeberg, Brown, & Elbedour, 2000; Martin & Kelly, 1999; McCall, 2008). These criteria, however superficial they may be, frequently, translate into the formation of widespread societal biases and stereotypes, and over the course of time, influence women’s exercise of educational and vocational choices (Eccles, Barber, & Jozefowicz, 1999; Lytton & Romney, 1997; Muller, Stage, & Kinzie, 2001).

The distinctions between genders are associated with another bleak component—the negativity attached to women’s presence in so called masculine fields (Ceci & Williams, 2007; Hill, Corbett, & Rose, 2010; Lytton & Romney, 1997; Muller, Stage, & Kinzie, 2001; Wang, Oliver, & Staver, 2008). Generally speaking, women are perceived to be less capable of demonstrating success within male dominated fields; if in fact they do succeed, they are also seen as relatively less affable (Halpern et al., 2007; Hill, Corbett, & Rose, 2010; Wang, Oliver, & Staver, 2008). Because “both likeability and competence are needed for success in the workplace; [therefore], women in STEM fields can find themselves in a double bind” (Hill, Corbett, & Rose, 2010, xvi). The ‘double edged sword’ has profound impact on women’s long-term prospects in STEM fields (Eccles, Davis-Kean, & Simpkins, 2006; Eccles, Barber, & Jozefowicz, 1999; Halpern et al., 2007; Wang, Oliver, & Staver, 2008). Unfortunately, even as the scores obtained by girls in math and science courses and their performance on standardized tests continue to show steady improvement, the existence of contradictory beliefs among girls is quite extensive (Ceci & Williams, 2009; Jacobs & Simpkins, 2005; Mullis et al., 2000; National Center for Education Statistics, 2009; National Science Board, 2008, 2010).

Interestingly, recent research in this field has also revealed some paradoxes, further, which may be indicative of the double bind that females perceive themselves to
be in (Hill, Corbett, & Rose, 2010; Wang, Oliver, & Staver, 2008). For instance, on one hand, girls assess their abilities in math and science at levels lower than those of boys; on the other hand, girls hold “themselves to a higher standard than boys do in subjects like math” (Hill, Corbett, & Rose, 2010, xv). The prevalence of paradoxical beliefs among girls create far-reaching consequences, and “have been found to limit girls’ interest in mathematics and mathematically challenging careers” (Hill, Corbett, & Rose, 2010, xv; see also, Ceci & Williams, 2009; Francis & Skelton, 2005; Jacobs & Simpkins, 2005; Mullis et al., 2000; National Center for Education Statistics, 2009; National Science Board, 2008, 2010). Furthermore, it has been seen that females are more likely than males to actively seek out occupations related to societal causes and welfare (Eccles, Barber, & Jozefowicz, 1999; Eccles, Davis-Kean, & Simpkins, 2006). Conversely, males are more likely to seek opportunities leading to higher levels of success in shorter time periods, and also those esteemed higher by society (Eccles, Barber, & Jozefowicz, 1999; Harris Interactive, 2006).

Racial and Ethnic Differences in the STEM Pipeline

The constraints associated with recruitment and retention of racial and ethnic minorities within STEM fields demonstrate similarities as well as some distinctions to those identified among females (Eccles, Barber, & Jozefowicz, 1999; Katehi, Person, & Feder, 2009; Lacey & Wright, 2009; Jacobs & Simpkins, 2005; National Center for Education Statistics, 2009; Vogt, Hocevar, & Hagedorn, 2007). Although in agreement about the importance of investigating gender differences within STEM fields, Muller, Stage, & Kinzie (2001), also emphasize a necessity for studying racial and ethnic groups
within each gender based study. Based on criteria established by federal organizations and as mentioned in Chapter three also, this dissertation study recognizes Black, Hispanic, and Native American\textsuperscript{5} students as racial and ethnic minorities within the STEM pipeline \cite{national2009, national2008, national2010; see also lacey2009, jacobs2005}.

\textit{Findings from Extant Research}

Total numbers of minority students who participate in the STEM pipeline have been increasing; however, the growth is mostly credited to increased participation of Asian students \cite{jacobs2002}. Black, Hispanic, and Native-American students continue to be underrepresented in majority of STEM fields \cite{jacobs2002, jacobs2005, national2009, vogt2007}.

Research indicates during the past several decades in the United States, participation in STEM pipeline, has been indicative of outflow rather than inflow \cite{drew1996, eccles2005, hanson2004, hill2010, jacobs2005, katehi2009, muller2001, national2009, vogt2007}. Additionally, the cumulative impact of differences witnessed among racial/ethnic sub-groups has

\footnotesize{The extremely low participation levels of Native Americans in higher education are not sufficient to yield detailed information about their recruitment and/or retention in STEM fields \cite{national2009}. However, in general, researchers agree that Native Americans pursue the STEM pipeline at levels equal or lower than Hispanic students \cite{national2009}.}
resulted into higher detrimental impact than gender based disparities (Hill, Corbett, & Rose, 2010; Muller, Stage, & Kinzie, 2001). Also worth noting:

The limited research that has addressed the interaction of gender and race-ethnicity generally shows that in each racial-ethnic category males outperform females in science achievement. The gender gap favoring males not only appears consistently across all racial-ethnic groups, but the pattern appears to be consistent throughout middle and high schools, with the differences widening sharply by Grade 12.
(Muller, Stage, & Kinzie, 2001, p. 984)

Frequently, differences among racial and ethnic groups, appear as early as middle and high school years (Jacobs & Simpkins, 2005; Katehi, Person, & Feder, 2009; Zarrett & Malanchuk, 2005). For instance, Muller, Stage, & Kinzie (2001) found that achievement levels of Black and female Hispanic students in 12th grade are lower than those of Asian and White students in 8th grade science. In other words, by end of 8th grade, large numbers of Asian and White students perform at higher levels than Black and Hispanic students in 12th grade. Likewise, a longitudinal study tracking progress of 12,000 underrepresented minority students in STEM fields, concluded that by the end of high school, Black and Hispanic students demonstrate stark variations in comparison to Asian and White students (Anderson & Kim, 2006).

The National Science Board (2008) found that in comparison to 31 percent Asians and 16 percent White students who complete a course in calculus, only 6 percent Black and 7 percent Hispanic students demonstrate similar academic trajectories during high school years. Thereafter, the gaps continue to increase steadily, peaking at graduation from college when numbers of Black and Hispanic students who complete STEM degrees demonstrate precipitous declines (Anderson & Kim, 2006). Similar findings can also be
seen in "The Science and Engineering Workforce: Realizing America’s Potential" study, conducted by National Science Foundation (2004): 1) Asians comprise 4% of all 24 year olds; however, they receive more than 15% of total engineering degrees; 2) Underrepresented minority students—Black, Hispanic, and Native Americans receive 10% of total numbers of Bachelor’s degrees; however, their numbers drop to fewer than 3% of total STEM degrees; 3) Though Hispanics comprise more than 12% of the total US population, they earn 7.2% and 6.7% of degrees in engineering and computer sciences respectively.

The glaring differences among ethnic and racial groups, have created another reason of anxiety among educators and policy makers (Katehi, Person, & Feder, 2009; National Science Board, 2008; Zarrett & Malanchuk, 2005). The discrepancies gaining strong footholds during secondary school years continue to expand during post-secondary years. Approximately, 50 percent Asian students matriculate in STEM majors versus 19-23 percent for Black, Hispanic, and White students (Anderson & Kim, 2006; National Center of Education Statistics, 2009). Current trends indicate that future prospects for Hispanic and Native American students in STEM fields are rather discouraging, and even more dire looking for Black males and Hispanic females (Hill, Corbett, & Rose, 2010; National Center of Education Statistics, 2009; National Science Board, 2008).

Cultural, Social and Familial Attributes

Beyond the inconsistencies and gaps seen across differences of gender, race, and ethnicity, some additional differentiators have been identified in the STEM pipeline. These include students’ age and levels of academic preparation, and families’ social class
and linguistic abilities (Anderson & Kim, 2006; Jacobs & Simpkins, 2005; McDonough, 1997; Muller, Stage, & Kinzie, 2001; National Center of Education Statistics, 2004, 2009; National Science Board, 2008, 2010; Prins & Tosso, 2008; Wang, Oliver, & Staver, 2008).

Collective findings by the Congressional Commission on the Advancement of Women and Minorities in Science (2000); National Center of Education Statistics (2004, 2009); and National Science Board (2008, 2010), reveal that percentages of students successfully entering STEM fields at post-secondary levels are higher for students younger than 19 years. Foreign born students matriculate into STEM degrees in higher percentages than US born students of similar ages (34 percent versus 22 percent). Familial characteristics have substantial impact as well; students from higher income families and college educated parents demonstrate distinct advantages over students from working class families and/or parents with incomplete high school education (National Center of Education Statistics, 2004, 2009). Similarly, students who take trigonometry and calculus classes during high school, and obtain higher scores on standardized assessments fare better (National Center of Education Statistics, 2004, 2009). Within the demographic and academic attributes of STEM entrants, there some anomalies:

A higher percentage of students age 30 or older, from families with income in the bottom 25 percent, and with an average high school GPA of below B entered the computer/information science fields than did students age 19 or younger, from families with income in the top 25 percent, and with an average high school GPA of B or higher. (National Center of Education Statistics, 2009, p. 7)

The above understandings make it apparent that within its current configurations, the STEM pipeline bodes relatively well for students with stronger academic and middle class backgrounds, and offers relatively reduced prospects for students from weaker
academic and working class or low income backgrounds (Congressional Commission on the Advancement of Women and Minorities in Science, 2000; National Center of Education Statistics, 2009).

Sources of Influence and Mitigating Factors

Scholarly examinations have indicated that in addition to social class differences, youth are influenced by a variety of factors including parental expectations and respective levels of involvement, the learning environment within schools and neighborhoods, support and guidance provided by teachers and guidance counselors, and the influences of peers (e.g., Cleaves, 2005; Halpern, 2007; Picklesimer, Hooper & Ginter, 1998; Prins & Tosso, 2008; Wang, Oliver, & Staver, 2008).

The timing and quality of experiences within a students' learning curve are critical for determining their success levels (Simpkins, Davis-Kean, & Eccles, 2006). Many researchers agree that large numbers of students acquire similar skills in elementary grades; differentiations start emerging during middle school and continue to widen by the time students reach high school (e.g., Greenfield, 1996; Jacobs & Simpkins, 2005; Simpkins, Davis-Kean, & Eccles, 2006). Other researchers claim that attrition from the STEM pipeline, especially within physical sciences, engineering, and mathematics happens during latter half of secondary years (e.g., Jacobs & Simpkins, 2005; Kahle, 2004; Vogt, Hocevar, & Hagedorn, 2007). However, Muller, Stage, and Kinzie (2001) disagree, and instead, posit that attrition from STEM fields has worsened by beginning earlier than was previously thought, during elementary school years.
Career Choices and Aspirations

For a clear majority of students, the path to educational and career choices starts with making decisions about course selection at secondary levels, and then, continues into selection of majors at post-secondary levels (Cleaves, 2005; Vogt, Hocevar, & Hagedorn, 2007). Adolescents’ personal awareness about STEM fields is perceived to be important during critical time periods when attrition from the STEM pipeline is at its highest levels (Bybee & McCrae, 2009; National Association for Research in Science Teaching, 2008).

There is clear evidence of reciprocity between self-concepts and academic achievement among youth (Jayratne, Thomas, & Trautman, 2003; Mullis et al., 2008; Wang, Oliver, & Staver, 2008). Based on self-proclaimed aspirations, students can be segregated into two key groups—1) those who plan for long term goals emphasizing college and professional careers; 2) those who target short-term goals emphasizing vocational tracks and immediate entry into the workforce (Picklesimer, Hooper & Ginter, 1998). Fortunately, though early childhood experiences are instrumental in shaping the self-identities of boys and girls, the formation of self-identities do not remain fixed (Hill, Corbett, & Rose, 2010; Simpkins, Davis-Kean, & Eccles, 2006).

Based on high school students’ decision-making processes, Cleaves (2005) conceptualizes five kinds of groupings:

1. Directed Trajectory—specified by long term commitments made during high school
2. Partially Resolved—specified by less focused ideas however possibilities are under serious consideration
3. Funneling Identifier—specified by a gradual narrowing down of ideas
4. Multiple Projection—specified by constantly fluctuating ideas
5. Precipitating Trajectory—specified by vocationally uncommitted students

Carol Dweck, a developmental psychologist at Stanford University, has added to this area of research by proposing suppositions informing the positive or negative impact of students’ self-beliefs and self-identities (Dweck, 2006a, b). Dweck (2006a) found that from middle school through college, students demonstrate even distributed across one of two possible domains: growth mindset or fixed mindset. A growth mindset is characterized by students’ beliefs that an adverse or a challenging learning situation can be overcome through hard work and perseverance. Students of this mindset are able to demonstrate perseverance within steep learning curves and short-term disappointments due to their ability to view challenges as unavoidable characteristics of learning processes.

Students who are disposed towards a fixed mindset are likely to believe that challenges are indicative of lower abilities, and therefore, tend to give up when faced with adverse situations (Dweck, 2006b). The impact of an individual’s mindset often does not emerge unless faced with significant challenges (Dweck, 2006a, b). Most students with fixed mindsets are likely to remain unaffected in any negative way during elementary school years. However, significant differences are likely to emerge between the two mindsets during middle school years, and, may create significant disadvantages for affected students (Dweck, 2006a, 2006b; Hill, Corbett, & Rose, 2010). Amidst the often portrayed dire picture regarding STEM fields, emergent research is contradicting prior understandings regarding students’ perceptions about their self-abilities:
Most students understand that math and science skills can be learned and developed, and that doing well is not simply a matter of innate ability. Among students, 70 percent said that math ability is something that people can learn and develop, versus 25 percent who said math ability is primarily innate. (Commission on Mathematics and Science Education, 2009, p. 13)

Such findings have encouraged educators to believe that broadening of the STEM pipeline and leveling inconsistencies within its current dynamics are distinct possibilities (Zweig, 2004).

Summary

The changing demography in the United States and staging of multiple global trends have contributed to current characteristics as well as emerging challenges of the STEM pipeline (Ceci & Williams, 2009; Hill, Corbett, & Rose, 2010; Jacobs & Simpkins, 2005; National Center for Education Statistics, 2009; National Science Board, 2008). In general, participation levels in STEM fields have increased among many students. Though these increases are welcome, and viewed as harbingers of future positive outcomes, they are also demonstrative of gaps across gender and social class differences, among different racial/ethnic groups, and particularly within physical sciences, engineering, and mathematics (Ceci & William, 2009; Eccles, Davis-Kean, & Simpkins, 2006; Halpern et al., 2007; Harris Interactive, 2006; National Center for Education Statistics, 2009; National Science Board, 2008; Vogt, Hocevar, & Hagedorn, 2007).
Part II: Parental Involvement

Introduction

Research has finally caught up with centuries of commonplace wisdom by providing verifiable evidence to conclude that parents play a critical role in the growth and academic progress of their children (Bouffard & Weiss, 2008; Lareau, 2003). Parent involvement\(^6\) is commonly recognized as a collective term for all engagements undertaken by parents in order to promote their children’s physical and emotional development, and academic and behavioral positive outcomes (Bouffard & Weiss, 2008; Cucchiara & Horvat, 2009; Epstein & Sanders, 2001; Epstein & Sheldon, 2006; Kao, 2004; McGrath & Kuriloff, 1999; Muller & Kerbow, 1993; Ream & Palardy, 2008; Weiss, Hoffman, Post, Bouffard & Little, 2005). It is widely acknowledged that advancement of their children’s well-being requires parents to make generous contributions of “time, energy, and material resources” (Hays, 1996, p. 8; see also, Bouffard & Weiss, 2008; Epstein & Sheldon, 2006). Furthermore, “when parents become involved in their children’s education, students tend to do better in school” (Epstein & Sanders, 2001, p. 414), and through their support, parents are able to effectively “prepare their offspring for expected threats and opportunities” (Ferguson, 2008, p. 18; see also Kao, 2004; Ream & Palardy, 2008). A critical look at the extant body of research regarding parent involvement reveals the inclusion of some often cited

\(^6\) A number of researchers use the term “parent involvement” to recognize the impact of parents’ efforts on children’s well-being and education, while some others use “parent support” to acknowledge the relationships (Bouffard & Weiss, 2008; Cucchiara & Horvat, 2009; Epstein, 2001; Epstein & Sanders, 2000; Epstein & Sheldon, 2006; Lareau, 2003). In this dissertation parent involvement and parent support will assume to imply the same kind of engagement and ensuing effects. As such these terms will be used interchangeably.
Making Sense of Terminology

Social Class

Social class is understood as a group of people with similarities across attributes of income and education (Beeghley, 2004). Through a combined usage of indicators alluding to personal income and education levels, sociologists usually distinguish three major categories within the larger population—upper class, middle class and working class (Gilbert, 1998). The upper class constitutes less than ten percent of US population, and generally speaking, it is assumed that parents belonging to this category possess all necessary human and material resources required for executing parental responsibilities (Davis-Kean, 2005; Gilbert, 1998). The middle class constitutes upwards of 35 percent and usually less than 50 percent of households/individuals in the US; as such, it is understood that middle class parents have incomes which are sufficient for affording comfortable standards of living (Gilbert, 1998; Zweig, 2004). A second important identifier of middle class is attainment of higher education (Beeghley, 2004; Davis-Kean, 2005). Middle class parents are thought of as well-informed and influential in establishing precedents in schools and capable of making demands benefiting their children (Cucchiara & Horvat, 2009; Davis-Kean, 2005; Epstein, 2001; Lareau, 2003; McGrath & Kuriloff, 1999). Because of the simultaneous presence of adequate income and acquisition of higher education, it is often perceived that middle class parents provide optimum levels of support for their children (Epstein, 2001; Lareau, 2003). For an
extended period in the history of the United States, White people from higher financial backgrounds were treated as the default representations of middle class (Beeghley, 2004; Zweig, 2004).

Historically, a working class individuals are almost universally associated with an absence of characteristics that define middle class i.e. lack of college education and inadequate income (Zweig, 2004). Gilbert (1998) estimates, that depending on economic cycles, approximately 40 percent of Americans are likely to be classified as working class people. People whose incomes qualify them for federal and state subsidies are often included in low income groups (Beeghley, 2004; Gilbert, 1998). Based on broad demographic indicators, it is often assumed that the working class and low income groups are inclusive of large numbers of ethnic and racial minorities (Beeghley, 2004; Zweig, 2004). However, more recent reports posit that numbers of White people within working-class and low income groups are surging; magnitudes of these kind have not been witnessed in previous decades (Beeghley, 2004; Bouffard & Weiss, 2008; Zweig, 2004). Contrary to popular prior conceptions, increasing numbers of ethnic and racial minorities are not included in working class or low income groups (Zweig, 2004).

Understanding the dynamics of social class in US has become important in the context of K-12 education because a growing body of literature on social class and parental involvement indicates a clearly intertwined relationship between these two attributes (e.g., Cucchiara & Horvat, 2009, Lareua, 1989, 2003; McGrath & Kuriloff, 1999; Ream and Palardy, 2008). These researchers claim that social class differences in the larger society reverberate in the form of unequal parent involvement in schools (e.g., Cucchiara & Horvat, 2009; Ream and Palardy, 2008). However, some others, such as
Pattillo (2008) posit that social class differences among parents are influenced by the dynamics of their neighborhoods. Middle class citizens tend to focus on procurement of amenities and resources (including schools) that are of high quality and aesthetically pleasing, whereas working class and low income families are concerned with providing basic services that are easily accessible and affordable in nature (Pattillo, 2008). The socio-economic differences seen among parents have led to other understandings. For example, Lareau (1987, 2000) postulates that middle class families construct interdependent relationships with schools whereas working class families demonstrate inclinations towards independent relationships with schools. As a result, middle class families engage in “concerted cultivation” (Lareau, 2003, p. 237) of their children’s education by providing material resources and emotional encouragement, securing academic and non-academic support within schools, and supporting participation in out-of-school opportunities (Bouffard & Weiss, 2008; Crew, 2007; Cucchiara & Horvat, 2009; Epstein & Sanders, 2000; Greenfield, 1996; Gonzalez-Pienda, et al., 2002; McGrath & Kuriloff, 1999; Ream & Palardy, 2008). Simultaneously, it is understood that working class parents consider their involvement as important too; however, they tend to view their children’s welfare within a dichotomy within which parents are responsible for physical and emotional well-being, and schools for academic development (Lareau, 1989; 2002). Often, this has led to hasty perceptions within school systems that working class parents do not view involvement in children’s education as crucial (Lareau, 1989; 2002).

Some other researchers view that because working class and low income parents often possess limited access to informational resources, in turn, this leads to lack of
know-how about educational systems, and subsequently, inability to advocate for their children within school systems (e.g., Crew, 2007; Gonzalez-Pienda, et al., 2002; Pattillo, 2008). The affordances and variations seen within parenting practices across social class differences, often, have led to idealistic perceptions about middle class parenting practices (Bouffard & Weiss, 2008; Crew, 2007; Gonzalez-Pienda, et al., 2002; Lareau, 2003; Prins & Willson Toso, 2008).

Social Capital

Also used frequently in the field of economic sociology, social capital is defined as “the capacity of individuals to command scarce resources by virtue of their membership in networks or broader social structures” (Portes, 1998, p. 12; see also Cucchiara & Horvat, 2009; Epstein & Sanders, 2000; McGrath & Kuriloff, 1999). Bourdieu (1986) has explained social capital as the reproduction of power and privilege across social differences (see also, Portes, 1998).

Within domains of parenting practices and parent support, social capital can be explicated as the sum total of all resources, information, behaviors, and opportunities that parents are privy to as a result of their relationships with other people (Cucchiara & Horvat, 2009; Horvat, Weininger & Lareau, 2003; McGrath & Kuriloff, 1999; Pong, Hao, & Gardner, 2005; Ream & Palardy, 2008; Sheldon, 2002). Thus, parents’ possession of social capital enables them to secure “the conversion of actual or potential resources embedded in social networks into other more tangible [benefits]” (Ream & Palardy, 2008, p. 240). Thereafter, by capitalizing on the relationships and subsequent accrual benefits, social capital enables parents to shepherd their boys and girls towards
preferred and selective opportunities within school systems (Epstein & Sanders, 2000; Horvat, Weininger & Lareau, 2003; McGrath & Kuriloff, 1999; Ream & Palardy, 2008).

Two groups of further insights can be surmised from extant research: first, advantages obtained from enhanced social capital are suggestive of superior access to resources among middle class parents in comparison to those from working class backgrounds. Second, advantages secured through parental exercise of social capital have been known to accrue into higher levels of student achievement (Bourdieu, 1986; Horvat, Weininger & Lareau, 2003; McCall, 2008; McGrath & Kuriloff, 1999; Ream & Palardy, 2008).

Parent Teacher Association

Reinforced by over 100 years of experience working with parents and schools, the Parent Teacher Association\(^7\) (PTA) is an active advocate of parent involvement in children’s K-12 education (Johnson, 2008; National Parent Teacher Association, 2006). By addressing issues related to the education, health and welfare of children, the PTA views itself as an activist on behalf of all parents (National Parent Teacher Association, 2006). With the help of many other education and health organizations, in 1997, PTA developed standards which function as guidelines to define and promote parents’ involvement in K-12 educational systems (Johnson, 2008). According to PTA standards, two key factors enable parents’ involvement in children’s education within the school systems: 1) regular two-way communication between home and school, and 2) parents

\(^7\) More information on PTA and recently revised PTA standards can be obtained from http://www.pta.org
being perceived as active partners of teachers, in classrooms and schools (Crew, 2007; National Parent Teacher Association, 2006).

**School Volunteers**

Epstein (2001) identifies school volunteers as people who support goals of schools and teachers by contributing time, effort, and expertise in order to work directly with children or support children's learning and well-being through indirect means such as providing assistance in libraries and cafeterias, organizing school-based events, and fund-raising for additional learning opportunities taking place at school.

**Out-of School Time**

The out-of school time (OST) includes various types of learning opportunities offered to K-12 students in after-school hours, and during weekends and summer breaks (Basu & Barton, 2007; Bouffard & Weiss, 2008). Multiple institutional entities offer OST instruction; these include K-12 schools, museums, research organizations and universities, and local and regional public institutions. Within the last two decades, the frequency with which OST programs offer STEM learning for K-12 students has experienced remarkable growth (Basu & Barton, 2007). Additionally, it has been witnessed that current OST programs are offering STEM learning opportunities for a wider range of age groups in comparison to those in previous two decades (Basu & Barton, 2007). The benefits of OST programs extend beyond students: for instance, Bouffard & Weiss (2008) postulate that being involved in OST programs assist parents for developing liaisons with other parents as well as with OST mentors and instructors. If
the postulations offered by Bouffard and Weiss (2008) are credible, then, it is likely that
OST programs have potential for facilitating parents' introduction to beneficial
relationships and access to opportunities to develop awareness of knowledge and
opportunities that normally may not have been within their reach (see also Ream &
Palardy, 2008; Weiss et al., 2005).\footnote{More details on OST programs have been provided in chapter 5}

**Key Understandings Regarding Parent Involvement**

In the recent decades, several large scale and ongoing studies attest to the
importance of parent involvement as well as reveal an increased level of research in this
field (e.g., Epstein & Sanders, 2001; Fredericks, Blumenfeld, & Paris, 2009; Gonzalez-
Pienda, et al., 2002; Harvard Family Research Project, 2008; Henderson, Mapp, Johnson
& Davies, 2007; Weiss et al., 2005). As a result of increased emphases on school reform,
the role of parents in children's education is receiving renewed attention (e.g., Bouffard
& Weiss, 2008; Weiss et al., 2005). For the purpose of framing extant literature for this
dissertation, the following groups of understandings regarding parent involvement are of
significance:

**Changing Dynamics of Family Support**

In comparison to the trends witnessed a few decades ago, families demonstrate
complex structures; due to myriad factors, adults are often necessitated to assume several
responsibilities, both, inside and outside of home (Crew, 2007; Weiss et al., 2005).
Familial attributes witnessing rapid growth in the last few decades include dual income
families, households headed by single parents or non-parent adults, and diversity across characteristics of race, ethnicity, and heritage languages (Crew, 2007; Ream & Palardy, 2008; Weiss et al., 2005). The change in familial attributes may result into distinct advantages or obstacles depending on the context within which children are raised (Davis-Kean, 2005; Weiss et al., 2005). Contrary to previous findings about the importance of parent involvement during early childhood years, now, researchers posit that parent involvement is critical for all age groups and especially during adolescence when youth are required to make decisions with potential long term impact (e.g., Bouffard & Weiss, 2008; Crew, 2007; Davis-Kean, 2005; Weiss et al., 2005).

During early childhood years, parents’ involvement in children’s learning is prevalent in the form of homework help, shared reading practices, and volunteering within school or PTA sponsored activities. As children get older, parent involvement primarily takes form through home-based interventions such as guidance about course selection and college planning, expectation setting, and monitoring of academic and behavioral growth (Bouffard & Weiss, 2008; Henderson, Mapp, Johnson & Davies, 2007). Research conducted under auspices of the Harvard Family Research Project concludes that families can best support their children’s growth and achievement through a complementary process that “intentionally integrates school and non-school [resources] to promote educational and life success” (Bouffard & Weiss, 2008, p. 3).

For an extended period in the history of K-12 schools after the notion of parent involvement became widely recognized, parents were recognized as schools’ partners in educating youth; however, only within the confines of selected opportunities ‘permitted’ by school personnel (Bouffard & Weiss, 2008; Crew, 2007; Henderson, Mapp, Johnson
& Davies, 2007; Weiss et al., 2005). In a contentious spirit, Crew (2007), repudiates traditional perceptions of parents as passive recipients, instead, espouses the important roles of parents in their children’s education by “[demanding] things from their schools because they understand that they are indeed owed something and it is their responsibility to get it for their children” (p. 155).

Understanding Modes of Parent Support

Primarily based on the level of authority exercised on children, Baumrind (1971), conceptualized three models of parenting: permissive, authoritarian, and authoritative. The permissive parent places few expectations or limitations on the child, often, resulting in home environments where children grow amidst inconsistent rules and expectations, and are often supplied with external incentives in order to attain compliance. Authoritarian parents are recognized as those who use excessive discipline and punitive controls to ensure their children’s acquiescence. Finally, authoritative parents are seen as an optimum blend of permissive and authoritarian parenting, using a judicious mix of firm limit setting, clear expectations, and emotional support, all of which are negotiated through a process of respectful and bi-directional communication with their children (Baumrind, 1971; 1989). Just as middle class parents have been perceived as the epitomized group among parents, frequently, authoritative parenting practices is seen the ideal model (Baumrind, 1971; 1989; Querido, Warner, & Eyberg, 2002). In general, it has been found that middle class parents ascribe to authoritative parenting practices more than parents from working class backgrounds.
Baumrind’s (1971) categorization of parenting styles has been studied quite extensively; however, efforts to understand respective implications across cultural differences are more recent (e.g., Prins & Willson Toso, 2008; Querido, Warner, & Eyberg, 2002). Parents of Asian and White backgrounds are more likely to embrace authoritative parenting than Black and Hispanic parents (Henderson, Mapp, Johnson & Davies, 2007; Lareau, 2003; Prins & Willson Toso, 2008; Querido, Warner, & Eyberg, 2002). Recently, many of these assumptions are being challenged. More recently, some researchers have drawn associations between parenting styles using indicators of social class instead of relying on race and ethnicity as absolute gauges (e.g., Cucchiara & Horvat, 2009; Henderson, Mapp, Johnson & Davies, 2007; Lareau, 2003; Prins & Willson Toso, 2008; Querido, Warner, & Eyberg, 2002). Amidst the continuously evolving theories regarding parenting practices, one understanding has remained constant: there is direct and predictable correlation between the presence of caring parental practices at home and positive outcomes among children (Baumrind, 1971, 1989; Bouffard & Weiss, 2008; Querido, Warner, & Eyberg, 2002).

In terms of location of intervention, parent involvement is recognized in two distinct categories: at school and at home. At school, parent involvement is witnessed in the form of volunteering to support efforts of school personnel, engagement with schools and teachers, mediation on behalf of their children, and efforts towards affecting changes in school policies and practices (Cucchiara & Horvat, 2009; Epstein & Sanders, 2001; Henderson, Mapp, Johnson & Davies, 2007; Johnson, 2008; McGrath & Kuriloff, 1999). Swap (1993) visualizes parent support through a range of four variations, ranging from parents’ complete reliance on school systems to one where parents are perceived as
partners in the school systems (see also Crew, 2007). The operationalization of parent involvement is demonstrated in two ways: 1) Individualistic: as a single variable that represents efforts of an individual child’s parent(s); 2) Collectively: as a cumulative variable wherein parents of many children unite to either provide direct support and/or weigh on support provided by schools (Fredericks, Blumenfeld, & Paris, 2009; Gonzalez-Pienda, et al., 2002).

Home-based interventions are considered most impactful elements of parental involvement (Bouffard & Weiss, 2008). The two most commonly witnessed forms of home-based interventions are: 1) direct academic instruction and guidance given to children; and 2) reinforcement of children’s interests and learning processes through encouragement and providing material resources (Epstein, 1987; Epstein & Sanders, 2001; Weiss et al., 2005). The impact of parent involvement on hesitant and/or semi-informed young people’s minds, often manifests as the difference between an individual student’s academic aspirations and actual levels of achievement (Bogue & Marra, 2009; Cleaves, 2005; Davis-Kean, 2005; Hanson, 2004; McCall, 2008). The support provided by parents may be a crucial factor in steering adolescents towards pursuing STEM educational and vocational opportunities, although it is not clearly known how parents provide their support (Bleeker, & Jacobs, 2004; Haste, 2004; Leonardi, Syngollitou & Kiosseoglou, 1998).

It has been found that the ways in which parents choose to support children are more often rooted in their self-beliefs and knowledge rather than external influences such as information disseminated by schools and teachers (e.g., Epstein & Sanders, 2001; Lee, 2002). As reiterated in an earlier part of this chapter, many students use opportunities
during high school years to narrow down their post-secondary options; however, several familial factors such as parents’ beliefs, expectations, and involvement are also influential within students’ decision-making processes (Cleaves, 2005; Jacobs & Simpkins, 2005; Lee, 2002). Current understandings are further complicated because the means and ways through which parents support their children are entrenched within several social and gendered attributes (Bouffard & Weiss, 2008; Epstein & Sanders, 2001; Lareau, 2003; Lee, 2002; Leonardi, Syngollitou & Kiosseoglou, 1998; Weiss et al., 2005).

The Relationships between Social Class and Social Capital

Social class differences get stratified further by the extent of social capital accrued by parents, inevitably, creating groups of insiders and outsiders among parents within school systems (Coleman, 1988; Horvat, Weininger, & Lareau, 2003; McGrath & Kuriloff, 1999; Portes, 1998). Some researchers explicate the relationships between social class and social capital by proposing that middle and upper middle class parents exercise higher levels of social capital in comparison to working class parents (e.g., Horvat, Weininger, & Lareau, 2003; McGrath & Kuriloff, 1999; Ream & Palardy, 2008). The divide between social classes is corroborated by a large body research on parent involvement highlighting the differences in the support provided by White, middle-class and Black, low income parents to their children.

For quite some time now, it has been widely recognized that parents with at least some level of higher education are more confident in advocating for their children in comparison to parents who lack experiences with higher education (Epstein & Sanders,
Therefore, parents from working class or low income groups are intimidated by the idea of engaging with school systems because they “lack well-informed sources of ideas about what to do” (Ferguson, 2008, p. 18). Similar kinds of obstacles have also been identified among ethnic and racial minorities and also recent immigrants, when engaging with school systems on behalf of their children (Kao, 2004; Stanton-Salazar, 1997).

Several researchers argue that middle class parents intervene with more ease on behalf of their children by securing extra privileges and benefits in the form of additional or superior resources, influencing school policy changes, interacting with school personnel, and seeking beneficial adjustments for their children (e.g., Cucchiara & Horvat, 2009; McGrath & Kuriloff, 1999; Stanton-Salazar, 1997). By making collective negotiations on their children’s behalf, middle class parents gain more bargaining power (Cucchiara & Horvat, 2009; McGrath & Kuriloff, 1999). Regrettably, the united efforts of middle class parents are not always egalitarian; frequently their efforts are exercised at the expense of children from working class or low income backgrounds (Cucchiara & Horvat, 2009; McGrath & Kuriloff, 1999; Ream & Palardy, 2008).

Collective efforts of comparably wealthy parents may, for example, influence school practices in ways that purported kinship-based and go-it-alone actions of the working poor, however forceful, do not. If links between actors in social groups are themselves dyadic and communal resources that facilitate the interchangeability of other kinds of more tangible resources...at the expense of outsiders who are often less effective in making such claims. (Ream & Palardy, 2008, p. 241)
Impact of Gendered Interactions between Parents and Children

Gender theories identify members of society and attributes related to them from a gender and power perspective. Additionally, understandings about either gender have been constructed in the form of widely held conceptualizations within the historical evolution of social interactions (Andersson, Hussenius & Gustafsson, 2009; Harding, 1986, 1991; Lorber, 2001). As a result, descriptions of genders and their corresponding roles, responsibilities, prerogatives, and expectations are value laden with historical perspectives; sometimes, erroneously (Eccles, 1994, 2006; Eccles, Barber & Jozefowicz, 1999; Harding, 1986, 1991; Lorber, 2001).

Differential Socialization of Boys and Girls by Fathers and Mothers

Parents’ ideas about appropriate roles and responsibilities of each gender are created through lengthy processes of self-negotiations encompassing reactions to gendered values, beliefs, and expectations (Andersson, Hussenius & Gustafsson, 2009; Perry, Pryzybysz, & Al-Sheikh, 2009). Students’ educational and vocational decisions can be directly linked to parents’ efforts towards affirming or confronting societal biases and stereotypes (Jacobs et al., 2002).

The internalization of gendered norms is likely to have a cascading effect on how parents support their boys and girls to explore and participate in STEM fields (Cleaves, 2005; Perry, Pryzybysz, & Al-Sheikh, 2009). Parents tend to interact differently with boys and girls, and in this way, can instill different values among their children and develop differentiated expectations regarding what is considered as gender normative (Andersson, Hussenius & Gustafsson, 2009; Eccles, 2006; Harding, 1991; Hyde, 2005;
McCall, 2008; Perry, Pryzybysz, & Al-Sheikh, 2009). The end results belong to a range of options within two extremes: parents can positively impact their children’s educational and vocational prognoses by either demystifying portrayal of genders within mass media or place limitations by perpetuating misconstrued messages (Davis-Kean, 2005; Harding, 1986, 1991; Lorber, 2001).

Greenfield (1996) studied four ethnic groups to co-investigate gender and ethnic differences as well as the interactive influences of gender and ethnicity on students and their parents. Starting from elementary school years, a few disparities can be witnessed in the types of physical resources and verbal guidance boys and girls receive from their parents. Often, girls are coaxed by parents to elect softer activities such as dance and music lessons, whereas boys are encouraged to participate in energetic activities that allow them to assemble, dissemble, create, and explore (Greenfield, 1996; see also Jacobs, 2005). These differential norms and expectations have remarkably variant influences on boys and girls (Francis & Skelton, 2005; Greenfield, 1996). Distinct differences can also be seen in the ways mothers and fathers bear influence on their children’s short and long term decisions (Rosser & Daniels, 2004). Comparatively speaking, mothers’ beliefs are more influential in steering their daughters rather than their sons; however, the same cannot be said regarding fathers’ influence on their sons or daughters (Haste, 2004; Kahle, 2004; Rosser & Daniels, 2004). In general, both parents routinely make more efforts on behalf of their daughters than sons (Eccles & Harold, 1993).

Greenfield’s (1996) findings have been confirmed more than a decade later by a large scale study conducted by the Mathematica Policy Research Group (Else-Quest,
Hyde, & Linn, 2010). It was found that girls’ achievements in math are inversely related to their fathers’ gender-based stereotypes; in contrast, boys’ mathematical achievements are reciprocally related to their fathers’ positive beliefs (Else-Quest, Hyde, & Linn, 2010).

Feminist scholars have highlighted advancements made by females in the last two decades—in overall participation—as well as penetration into more competitive fields like physical sciences, engineering, and pure mathematics; however, so far, advancements have been significantly short of expectations (e.g., Bleeker & Jacobs, 2004; Brickhouse, 2001; Cleaves, 2005; Eccles, 2006; Harding, 1986, 1991, 1998; Keller, 1985; Rosser, 1995, 2000; Rosser & Daniels, 2004). On the one hand, teachers and parents are advised to provide boys and girls with equitable encouragement and opportunities for succeeding within the STEM pipeline (Brickhouse, 2001; Cleaves, 2005; Eccles, 2006; Wharton, 2005). On the other, wide gaps continue to exist between boys’ and girls’ participation in most non-biological STEM fields (Harding, 1998; Keller, 1985; Rosser, 2006; Wharton, 2005). As a result, participation in the STEM pipeline is viewed within male/female dualisms, i.e. the norm for males versus females (Brickhouse, 2001; Rosser, 2006). The negative aspects of gendered biases and stereotypical beliefs can be seen among boys as well as girls. For example, as a result of prevalent biases and stereotypes existing in societal norms, many girls refrain from matriculating into schools of engineering and equally high numbers of boys are hesitant to enroll in schools of nursing (Cleaves, 2005; Harding, 1998; Keller, 1985; Rosser, 2006).
Attitudes towards parenting and corresponding support provided by mothers and fathers vary across racial and ethnic differences (Bouffard & Weiss, 2008; Garcia-Coll & Chatman, 2005; Muller & Kerbow, 1993; Park & Palardy, 2004; Prins & Willson Toso, 2008; Querido, Warner, & Eyberg, 2002). Historically, literature on parent involvement has identified low levels of involvement among racial and ethnic minorities (Muller & Kerbow, 1993; Park & Palardy, 2004; Reay, et al., 2007). However, over the last two decades, research findings regarding racial and ethnic differences have revealed several inconsistencies. For example, Muller & Kerbow (1993) found that after controlling for educational levels, White parents demonstrate higher levels of engagement in comparison to Asian parents but lesser than Black and Hispanic parents. However, Crosnoe (2001) found that parenting differences across race and ethnicity are greatly mitigated by students’ academic performance more than any other single attributing factor. For example, in general, Black students’ parents are more involved than their White counterparts; however, this is true only in the case of students in remedial tracks. Another example highlighting the discrepancies can be witnessed within higher levels of parental involvement among Asian students in remedial tracks than their counterparts in college preparatory tracks (Crosnoe, 2001).

In general, the reasons for low involvement among racial and ethnic minority families have been discerned within a lack of physical resources and information, low social capital resulting into insufficient socialization with other parents, resource dilution due to large and inter-generational families living in single households, and personal histories of negative associations or unfamiliarity with K-12 school systems (Bouffard &
Although research on parental involvement across differences of race and ethnicity is not extensive in general, understandings related to parental involvement among immigrants are particularly in early stages of development (Crosnoe, 2001; Kao, 2004; Muller & Kerbow, 1993; Turney & Kao, 2009). Often, immigrant parents face unique set of challenges that have diminishing impact on their involvement in children’s education at home or at school (Domina, 2005). A great majority of these challenges are grounded in the inabilities of immigrant parents to communicate effectively in English (Domina, 2005). Kao (2004) found that within ethnic groups, foreign born/immigrant parents are likely to get less involved in schools compared to native born individuals. A majority of extant literature identifies immigrants through a deficit model and fails to make sufficient accommodations for social class differences (Bouffard & Weiss, 2008; Domina, 2005; Kao, 2004, Turney & Kao, 2009).

The above findings are important to consider within dynamics of the STEM pipeline. For example, though it is known that more Asian than Hispanic students demonstrate higher levels of achievement in STEM fields; however, research indicates Hispanic parents are more involved than Asian parents (Crosnoe, 2001). Yet, parents of Asian descent are often perceived to be ‘model’ minorities regarding parenting practices (Querido, Warner, & Eyberg, 2002; Turney & Kao, 2009). Therefore, solitary findings regarding racial and ethnic groups lack meaningful application because the specificities between and among many sub-groups have not been fully explicated, and therefore, should not be used to make sweeping generalizations about any particular race or
ethnicity (Bleeker & Jacobs, 2004; Cleaves, 2005; Garcia-Coll & Chatman, 2005; Muller & Kerbow, 1993). Two facets critical to this dissertation emerge from extant literature:

1) large percentages of minority parents are also members of working class or low income groups, and therefore experience significant “barriers to involvement—such as financial and logistical constraints” (Bouffard & Weiss, 2008, p. 4; see also Reay, et al., 2007);

2) comparable levels of parental support provided by White and minority parents, usually translate into more benefits for children of White parents (Garcia-Coll & Chatman, 2005; Park & Palardy, 2004; Querido, Warner, & Eyberg, 2002; Reay, et al., 2007).

The Evolving Understandings

Common Critiques of Dominant Views

For some time now, a growing group of scholars has critiqued the understandings emerging from the dominantly used models of parenting practices and parent involvement (e.g., Garcia Coll & Chatman, 2005; Garcia Coll & Patcher, 2002; Davis-Kean, 2005; Epstein, 2001; Epstein & Sheldon, 2006; Horvat, Weininger, & Lareau, 2003; see also Prins & Willson Toso, 2008). In particular, three areas of contention are of relevance to this study: First, since most early “models of successful child development have been based on European American, middle class samples” (Davis-Kean, 2005, p. 295), this has led to generalized and erroneous assumptions about the existence of an ‘optimum’ model of parent involvement (Garcia Coll & Patcher, 2002). Parents from low income groups are often provided with advice based on the practices seen among parents from middle class backgrounds with stronger identities in school
systems (Lareau, 2002; Pattillo, 2008). In turn, this led to minimal investigations into the parenting practices of minority and non-mainstream parents (Garcia Coll & Chatman, 2005; Garcia Coll & Patcher, 2002; Kao, 2004). Second, the abstract creation of an ‘idealistic model of parenting’ has simultaneously led to the creation and widespread use of a deficit model to describe parenting practices of minority and working class parents (Garcia Coll & Patcher, 2002; Lareau, 2002, 2003). Finally, researchers have expressed concern against frequent tendencies of educators and child advocates to offer advice regarding parenting practices to minority and non-mainstream parents (e.g., Crew, 2007; Garcia-Coll & Chatman, 2005; Lareau, 2003).

However, there is an encouraging aspect in the emergent research regarding parents’ support of their children’s academic progress. In contrast to earlier beliefs regarding parent involvement, more recently, scholars emphasize that neither are the means through which parents provide support for their children fixed in conception, and nor is it judicious to establish any kind of generalizations impacting large groups of people without substantial evidence (e.g., Bouffard & Weiss, 2008; Crew, 2007; Garcia-Coll & Chatman, 2005; Lareau, 2002, 2003). Furthermore, as parents experience changes within their awareness about the importance of getting involved in children’s education and gain improved access to better quality resources, often, they make corresponding modifications (Ream & Palardy, 2008).
Summary

The two bodies of literature reviewed in this chapter are thought-provoking and simultaneously, suggestive of further exploration regarding parents’ involvement in their children’s participation in the STEM pipeline (Cleaves, 2005; Eccles, 2005; Park & Palardy, 2004). Research studies demonstrate parental support is unequally distributed within families, some parents are involved extensively, whereas, others are challenged by access to resources or awareness (e.g., Crew, 2007; Epstein & Sanders, 2001; Garcia-Coll & Chatman, 2005; Lareau, 2003; Prins & Willson Toso, 2008). Other researchers concur that participation in STEM has numerous kinds of benefits but also poses multitude challenges for students; however, many of these barriers can be mitigated through adequate support (e.g., Burke & Mattis, 2007; Hill, Corbett, & Rose, 2010; Jacobs & Simpkins, 2005). Though parental involvement is understood to be a critically influential factor in influencing children’s academic progress and achievement, extant research lacks in explicating insights related to the STEM pipeline. Understandings regarding the range and variation through which mothers and fathers from diverse backgrounds prepare their boys and girls to pursue the STEM pipeline are sparsely developed, thereby, making this study a meaningful exercise with strong potential to build upon extant research.
CHAPTER THREE: STUDY DESIGN AND METHODS

Introduction

The two bodies of literature informing the research questions of this dissertation reveal intriguing aspects: first, each group is inclusive of findings that appear to be antithetical in nature, and second, they are simultaneously demonstrative of concurrence along some key understandings. Put together, these two equally extensive bodies of literature underscore the need to investigate the ways and means through which involvement of fathers and mothers bears influence on boys and girls regarding their participation in the STEM pipeline. As such, amidst the extant research which often presents a rather dismal outlook on the vigor of the STEM pipeline in the United States, it becomes worthwhile to focus efforts towards unraveling details of parents’ support towards enabling their children’s success within the STEM pipeline (Congressional Commission on the Advancement of Women and Minorities in Science, 2000; National Science Foundation, 2008; President’s Council of Advisors on Science and Technology, 2010).

It is in the above context, that this dissertation aims to uncover and document the ongoing processes through which a group of fathers and mothers support and prepare their children towards exploring and entering the STEM pipeline. This chapter explicates the research methods used in the study, and accordingly, is divided into three parts. Part I provides details of the research context and site, and a brief overview of the study participants. This section also explains the appropriateness of this site in view of the research questions undergirding this dissertation. Part II outlines the underlying
theoretical frameworks guiding this study as well as the methods of data collection and analysis. Qualitative methods supported by basic quantitative data obtained from preliminary surveys were used to answer the research questions driving this dissertation. Part III provides details of procedural challenges experienced in this study followed by explanations of how this researcher resolved emergent concerns.

Part I: Research Context and Study Population

Nationwide, it is seen that a large number of students experience attrition from the STEM pipeline starting from middle school years, continuing through post-secondary education, and then, sometimes extending into occupational paths (American Association for the Advancement of Science, 2006; Jacobs, 2005; Lucena, 2000; Williams, 2000). The peak numbers of students’ exit from the STEM pipeline are generally witnessed during the last two years of high school (Lucena, 2000; Williams, 2000). This includes students who have had access to OST learning opportunities focused on STEM fields (Basu & Barton, 2007; Jacobs, 2005; Lucena, 2000; Williams, 2000). There can be no doubt that the declining numbers and trends within the STEM fields are worthy of concern and attention; however, simultaneously, they make strong case for thorough exploration of circumstances within which boys and girls achieve success in the STEM pipeline (Congressional Commission on the Advancement of Women and Minorities in Science, 2000; Hill, Corbett, & Rose, 2009; National Science Foundation, 2008; President’s Council of Advisors on Science and Technology, 2010; Williams, 2000).

This dissertation was guided by two primary goals. First, it aimed to collect information about the different ways through which individual parents offer support to
their children for successful entry into the STEM pipeline, and second, by uncovering the different ways, this study attempts to recognize the recurrent themes and central tendencies of parents' efforts through a process that encompasses explicating interactions between parents and children, providing details of resources used by them, and describing parents' respective attributions (Cleaves, 2005; Congressional Commission on the Advancement of Women and Minorities in Science, 2000; Duschl, Schweingruber, & Shouse, 2007; Gee, 1999; National Science Foundation, 2008; President’s Council of Advisors on Science and Technology, 2010).

Why this site?

This research study took place at an after-school STEM program: Access to Scientists and Engineers (ASE). After narrowing down the focus of this dissertation, I began to actively explore possible sites for conducting research for this study. A request for assistance regarding a grant proposal piqued my initial interest in exploring ASE program as a potential site (one of three) for conducting research. During interactions with several mentors and also with a few students, I discovered that during the last ten years, a large percentage of students participating in the ASE program have successfully transitioned into STEM fields each year. For instance in 2009, out of 41 students, 14 graduated from high school; among these, 12 matriculated into STEM related degrees at colleges and universities spread across the United States. Graduates of 2010, reveal comparable patterns of matriculation into STEM fields. From among the total 17

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9 ASE is a pseudonym
students (10 boys and 7 girls) who graduated in the 2010 academic year, 14 have matriculated into STEM related degrees.\textsuperscript{10}

In contrast to national trends which indicate that less than 15% of high school students matriculate into STEM degrees, it was evident that each year, significantly higher percentages of students from the ASE program demonstrate successful transitions into STEM fields (National Center for Educational Statistics, 2009; National Science Board, 2008). Informal conversations with mentors conveyed that they perceived parents' support as an important factor behind the students' success. Later, this was corroborated by several students who expressed similar sentiments. However, when pressed for details, neither mentors nor students were able to provide satisfactory details.

In comparison to national trends, such impressive percentages of matriculation into STEM degrees bring attention to not only the activities of students but also to the parents' efforts, thus making it an appropriate site for conducting this research study.

After gaining access to basic demographic information about the program which indicated a range of diversity among the students and their families, this site became a strong possibility. I also found that a new cohort of students was about to join the program. Based on the above, I felt confident about the opportune value and timeliness of conducting research among parents and students at this site. Therefore, soon after conferring with my dissertation advisor, I conveyed my interest in conducting research within the ASE program to its governing board comprised of six members from various professional backgrounds. To secure approval for conducting research, I was asked to

\textsuperscript{10} This study included students from 2009, 2010, and 2011 graduating classes; complete information is not available on graduating class of 2011.
submit a detailed proposal of the research, and make an oral presentation to the governing board of ASE program.

**Details of Research Site**

The ASE Program is located in a cosmopolitan urban area in the northeastern United States. Since its conception in 1999, ASE program has had a track record of mentoring high school students from diverse backgrounds by providing experiences in real-world applications of STEM fields. Through the program, students are able to interact with scientists and engineers, learn about STEM educational and career opportunities, engage with similarly inclined peers, and get acquainted with STEM vocabulary. Each year, the program undertakes the responsibility of mentoring 35-50 students. The professional core of the mentoring team consists scientists and engineers (n = 14)\(^{11}\) who contribute their expertise and time during evening hours and on weekends to work with high school students.

The program draws students from approximately 15 high schools including public, private, and parochial institutions, as well as a few home schooled students. Students are admitted to the program in their sophomore year, with a possibility of continued enrolment until graduation from high school; in general, most students are allowed to return in the following year(s) without being required to repeat the application process.

The distinguishing attributes of the ASE Program include high quality of mentorships, focus on increasing minority student participation, clear paths for students

\(^{11}\) The actual numbers of the mentors have fluctuated between 12 and 17 each year
to apply, test, and transfer their knowledge and skills to younger students and within the larger community, building scientific literacy, acquisition of professional attitudes and behavior, and involvement of alumni.\textsuperscript{12} According to the mentors and information gathered from program literature, many students demonstrate a deeper understanding of scientific and mathematical concepts at the end of their 2-3 years of participation in the ASE program. The high quality and success of the ASE program can also be identified through the low rates of attrition each year (< 10%), and continued participation of alumni (n=197) (Basu & Barton, 2007).

Admission to the ASE program is determined through a competitive process including potential applicants' responses to open-ended as well as multiple choice questions. A chief criterion for selection in the ASE program is a high level of interest in STEM fields which needs to be evidenced through students’ self-identification, such as course selection in science and mathematics, and prior STEM learning activities. Although there is no participation fee, students and their parents/families are required to incur some nominal expenses for travel and food. Applications are accepted starting from spring into late summer of each year, following which, a review of applicants takes place during early fall. Soon after this, applicants are informed about the mentors’ decisions regarding acceptance into the program. Then, in late fall of each year, mentors hold 4-5 introductory meetings, which are followed by quick paced and intensive biweekly sessions starting in the first week of January through the end of May.

\textsuperscript{12} Based on publications and website of the program
Process of Recruiting Research Participants

The population sample of this study included boys and girls enrolled in the ASE program and their parents. I began the process of recruiting and selecting participants during the fall of 2009 by attending two events at the ASE site, during which time, I met several students of previous year’s cohort. This was followed by presentation of the proposed research to the governing board of ASE program. After receiving the board members’ written permission, I shared the goals and anticipated procedures of the proposed research with the participant pool at the program’s annual “kick-off” event on January 9, 2010. All throughout the presentation, audience members were invited to ask questions, and many students and parents made inquiries of various kinds. Towards the end of the session, I provided all those present with a brief summary of the study as well as necessary consent forms; a few people signed consent forms on the spot. This primary recruiting event was followed by three weeks of extensive personal contact through email and phone, during which time also, I answered more questions and resolved participants’ concerns. Additionally, I made nine home visits to solicit individual parents’ participation. In one instance, I invited a participant who had already given consent, to accompany me for the purpose of communicating with another potential recruit. Recruitment of participants was complete within four weeks of the kick-off event.

More details are available in a later section
Sample Population

The parents of ASE students exhibit diversity across several characteristics.\textsuperscript{14} They also demonstrate wide distribution in their educational backgrounds—from GED to doctoral degrees—and occupational backgrounds—employment as hospitality staff to researchers at area universities and hospitals. Similar levels of diversity can also be seen across racial/ethnic backgrounds—the cohort (2009-2010) included students whose families are Asian, Black, Hispanic, Mixed Race, Native American, and White.\textsuperscript{15} Although parents are encouraged to take active part in the various events held under auspices of the program; however, parents’ participation in the program is not mandatory in order for students to avail any or all learning opportunities offered by the ASE program. Beyond a mixed representation of educational, occupational, and ethnic/racial backgrounds, the research sample also included three single parents who either have sole or shared custody of their children; one grand-parent who is the primary caregiver; two step-parents; two recent immigrants, one with limited proficiency in written and spoken English.

The research population also included boys and girls in grades 10, 11, and 12 from a mix of public (including charter), private, parochial, and home-based schools scattered throughout the city and surrounding areas. Among the students from private and parochial schools, about half from each group attend single gender institutions. Most students live within 10 miles of the program's physical location. However, a small number of students (< 20%) travel upwards of 20 miles to attend ASE program, out of

\textsuperscript{14} Further details about individual parents will be shared in later sections and chapters
\textsuperscript{15} Details regarding the nomenclature chosen for this study have been provided in a later section
these, many but not all, are driven to the site by their parents or participate in a car pool organized by the parents.

Many of these students had deep interest in STEM fields prior to joining ASE; several students claimed that their interest in STEM fields drew them to apply for enrollment in the ASE program. Majority students acknowledged that participation in the ASE program had not only strengthened their resolve to matriculate into post-secondary STEM fields, and also that participation in the ASE program had clarified some of their assumptions regarding the characteristics of STEM fields. As such, the characteristics of these students are indicative of high levels of interest and inclination towards entering STEM fields.

Part II: Research Methods

Research demonstrates that sustained participation in STEM fields is dependent on several factors, such as students’ gender and families’ social class (e.g., Burke & Mattis, 2007; Eccles, 2005; Haste, 2004; Hill, Corbett, & Rose, 2010; Kahle, 2004; National Center for Education Statistics, 2009; Sevo, 2009; Simon, 2004). Since, my goals for this study were to investigate, describe, and analyze the processes and resources through which a diverse group of parents supports their children’s pursuit of STEM fields, coupling qualitative research methods with preliminary surveys aimed at collecting basic information from the research participants made the most natural fit (Maxwell, 2005). Following which, I have worked towards identification and description of recurrent themes emerging from within parents’ accounts and attributions, and then
situating the emergent themes within the context of the entire research sample as well as extant research.

Throughout this study’s findings, I have situated the perspectives shared by the participants and possible corresponding implications within extant research, and then, explored how the findings of this dissertation confirm or digress from extant literature. This dissertation pays special attention to the findings of three recent and widely circulated reports, namely “Why so few? Women in Science, Technology, Engineering, and Mathematics” by the American Association of University Women (Hill, Corbett, & Rose, 2009); “The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy” by the Commission on Mathematics and Science Education (2009); and “Science and Engineering Indicators, 2008 by the National Science Foundation (2008).

Theoretical Frameworks and Underlying Premise

Social capital is the aggregate of the actual or potential resources that are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group.

(Bourdieu, 1983, pp. 102–103)

This study draws upon theories of social capital coupled with foundational understandings about social networks. For the purpose of this study, social capital is viewed as the accumulation of tangible assets, information, and knowledge about
information sources and connections with people of influence, together, which enable individuals or groups of individuals to use these to their advantage (Bourdieu, 1983; Coleman, 1988; Lin, 1999; Portes, 1998). Social networks are identified as unique sets of relationships with professional or personal acquaintances that individual people may use to acquire assets of social capital (Bourdieu, 1983; Coleman, 1988; Lin, 1999; Portes, 1998; Wanat & Zieglowsky, 2010).

In his seminal work on social capital, Coleman (1988) identifies three major forms: creation of obligations and expectations of a social group, the shared information between group members, and establishment of norms and guidelines to facilitate the interaction between and among members of the social group. Extant literature indicates that in order to acquire social capital, parents must be part of a social network (e.g., Bourdieu, 1983; Coleman, 1988; Wanat & Zieglowsky, 2010). Therefore, it becomes important to note that within an established social network, individuals may use information available to them without any sense of obligation or conditions (Coleman, 1988; Wanat & Zieglowsky, 2010). This leads to further understandings that in order to acquire higher levels of social capital, parents may need to have larger and stronger social networks (Bourdieu, 1983; Coleman, 1988; Cucchiara & Horvat, 2009; McGrath & Kuriloff, 1999; Wanat & Zieglowsky, 2010). The intertwined aspects of social capital and social networks inform the underlying bases of this dissertation.

Preview of extant literature has clearly demonstrated that multiple dimensions of social class are interspersed in overlapping ways, both within current understandings regarding the levels and range of parent involvement as well as within the demography of the STEM pipeline (e.g., Bourdieu, 1986; Commission on Mathematics and Science
Education, 2009; Eccles, 2006; Hidalgo, Siu, & Epstein, 2003; Lareau, 2003; National Science Foundation, 2008). Therefore, it appears that discovering links between economic and sociological thought processes and associated actions among parents may shed light on the parents’ means and attributions for supporting their children’s pursuit of the STEM pipeline (Eccles, 2006; Horvat, Weininger, & Lareau, 2003; Ream & Palardy, 2008). Researchers also posit that characteristics of social class parlay into varying levels of privileges within parents’ differential access to social capital (e.g., Horvat, Weininger, & Lareau, 2003; McGrath & Kuriloff, 1999; Portes, 1998; Ream & Palardy, 2008). They draw special attention to how social interactions among parents lead to the “accumulation and exchange of various kinds of educationally useful resources (Ream & Palardy, 2008, p. 240). In particular, this study focuses on the aspects related to parents’ capitalization of shared information, conditions enabling usage of shared information, and outcomes as identified by parents and children (Wanat & Zieglowsky, 2010).

Furthermore, research indicates that characteristics of social class manifest as functional (i.e., educationally useful) and reproductive (i.e., class-stratified) forms of parents’ social capital (e.g., Ream & Palardy, 2008; Stanton-Salazar, 1997). Accordingly, in this study, I have explored the entrenched linkages between social class and parents’ social capital, primarily, as a way to document these parents’ efforts to support their children and the associated meanings that parents ascribe to their efforts, and secondarily, to shed light on the current gaps and leaks within the STEM pipeline.

The underlying premise of conducting this study was that assessments would not be able to identify causal relationships between parents’ actions and ensuing impact on children, rather, create focused estimations of what transpires between parent and
children within the parameters of parents providing support for their children’s participation in STEM fields (Lareau, 1996; Maxwell, 2005). That said, assessments were generated in this study based on collected evidence, following which, qualitative methods were employed to situate the emergent assessments within contemporary research (Gee, 1999; Lareau, 1996; Maxwell, 2005).

Research Instruments

Since the underlying goal of selecting participants for a qualitative study is to make choices based on people’s abilities to provide necessary information for answering the research questions, random samples are not useful (Maxwell, 2005; Seidman, 2006). Additionally, in situations where participants’ consent is required, the process of self-selection is not entirely compatible with true randomness (Seidman, 2006).

Based on my estimations during early phases of the planning process, I had envisaged that a total of 16 participants (8 parents and 8 students) would be sufficient for adequately representing the research population. However, the introductory presentation succeeded in eliciting overwhelming enthusiasm among parents and students alike, and as a result, the consenting individuals were far in excess of proposed numbers. Eventually, 39 parents (18 fathers and 21 mothers) and 32 students (20 boys and 12 girls) including two foreign born and recent immigrants, signed consent forms. Though unprepared for this larger than anticipated undertaking, after a great deal of deliberation, I became inspired and confident about including more participants in the study. In hindsight the additional efforts proved to be worthwhile.
I started the dissertation process by conducting surveys among the larger group of parents and students to collect baseline data and set up a preliminary context for the rest of the research instruments. Following the completion of surveys, participants were selected for the remaining data collection phases which included interviews among parents and students, and focus groups among parents. As also mentioned earlier, the participants were not selected for the remainder of data collection through a process of random selection and random assignment; however, a number of criteria were used to guide the inclusionary process (Creswell, 2004; Maxwell, 2005).

The underlying purpose of interviewing a given number of participants is to resolve whether the data collected from them can be generalized to the larger population (Seidman, 2006). Seidman (2006) posits that qualitative research studies can achieve more generalizable results if they include the maximum possible variation among participants.\footnote{Also see Denzin & Lincoln (2000) (Eds.), \textit{Handbook of qualitative research} (2nd edition). Thousand Oaks, CA: Sage.} In this study, it was accomplished by selecting a sample capable of representing the entire group (Seidman, 2006). Two essential considerations guided the selection of participants for the remaining phases: a wide sampling was useful for establishing a level of credibility; beyond inclusion of sufficient numbers of participants, no new information was likely to be collected (Maxwell, 2005; Seidman, 2006). Based on the above criteria, participants were recruited through purposeful sampling\footnote{Purposeful sampling is a "strategy in which particular settings, persons, or activities are selected deliberately in order to provide information that can't be gotten as well from other choices" (Maxwell, 2005, p. 88). Creswell (2004) explicates four advantages for employing purposeful sampling: (1) it achieves representativeness of the large population within a small study sample; (2) it can adequately capture an essence of the heterogeneous characteristics of the population; (3) it allows an examination of the theories and/or themes that become apparent within the study; and (4) it illuminates the factors behind the divergence within the individual responses as well as the extreme cases in the entire range.} to ensure
inclusion of several characteristics. Parents were selected to include diversity across race, ethnicity, educational background, and occupations, and students were identified in ways that ensured an approximately even mix of genders, grade levels, schooling types, and location of schools. Additionally, in order to include the perspectives of one recent immigrant parent who had initially expressed some reticence, recruitment was done by using referrals from acquaintances (Maxwell, 2005).

Through a process of careful selection, I made attempts to include sufficient numbers of participants to ensure several configurations, i.e. approximately equal numbers of parents of boys and girls; inclusion of comparable numbers of mothers and fathers; parents employed in STEM and non-STEM fields; parents who feel positively about their children's participation in the STEM pipeline and those without strong opinions or with reservations; parents whose children attend mixed and single gender schools; parents who view parental involvement as a necessary aspect of their children's academic progress and those who indicate limited levels of involvement. Because the consenting participants spanned most of these dyads, I am confident that this process was able to create meaningful inclusion of the range and variation through which parents support their boys and girls, first to explore, and then, enter the STEM pipeline (Creswell, 2004; Eccles, 2005; Maxwell, 2005; Seidman, 2006).

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18 In the absence of access to complete educational backgrounds of several parents, frequently, their occupations were used as substitute indicators.

19 Snowball sampling is used to collect information from participants that have enrolled in a study through prior associations with previous acquaintances (Salganik, & Heckathorn, 2004). Using the analogy of a snowball that expands in girth as it rolls along the surface, snowball sampling refers to the increase in the sample size of the study population. Because this method of recruiting relies of referrals or word of mouth, it is often used to include participants, who otherwise might be inaccessible to the researcher or may be hesitant for a host of reasons to give consent for participation (Salganik, & Heckathorn, 2004). However, this form of recruitment is accompanied by some disadvantages too; chief one being that the sampling becomes dependent on prior associations and acquaintances, and thus, may not be able to provide an accurate portrayal of the sample population (Salganik, & Heckathorn, 2004).
Extensive interviews with parents and students were followed by four focus groups which included a further selected group of parents. In February 2010, two girls and one boy who had agreed to participate in the study dropped out because of their inability to balance school-work with out-of-school commitments. Subsequent conversations with mentors confirmed that it was typical for the program to experience a small level of attrition each year. However, because of the wider than expected sampling, it is highly probable that a small number of dropouts from the research study did not create any significant adverse impact on this study’s findings.

**Parent Surveys**

The surveys administered to parents targeted several categories of responses: demographic information on child and parent(s); parents’ perceptions regarding importance of STEM; resources provided by parents and their identification of the respective impact on children; parents’ understanding of the extent of children’s interest in STEM fields; parents’ self-identification of evidence pointing to children’s interest in STEM fields; and frequently used sources of information for the purpose of helping their children.

Out of the consenting individuals, 34 parents; 15 fathers and 19 mothers completed the parent surveys (in addition, two parents requested copies of the survey but did not complete). Survey respondents were requested to provide introductory information through a combination of Likert-scale values, and multiple choice and open-
ended questions. On an average, it took parents about 50 minutes to complete the survey.

The following, table 3.1 provides overall numerical distribution of the parents who completed the surveys.

<table>
<thead>
<tr>
<th>Racial/Ethnic Identities</th>
<th>Fathers</th>
<th>Mothers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Black</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mixed Race</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Native American</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>White</td>
<td>5</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15</td>
<td>19</td>
<td>34</td>
</tr>
</tbody>
</table>

**Student Surveys**

Similar to the parent survey, the student survey also targeted several introductory themes: demographic and academic information about students; construction of students’ perceptions regarding their importance of participation in STEM fields; extent of students’ participation in STEM activities at school and within OST opportunities; students’ identification of parents’ support; and students’ identification of perceived impact of parents’ support. From among the consenting students, 29 students, 18 boys

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20 See Appendix A for a sample of the parent survey
and 11 girls completed the surveys; these included eight 10th graders, five 11th graders, and fourteen 12th graders.

Since an underlying premise of including parents and students in the study was to collect comparative accounts of their respective understandings, extensive efforts were made to secure parent-student dyads. Except in three situations where parent-student dyads could not be completed, this was a successful goal: one student (White male) self-selected not to participate; two parents (one Asian; one Black) completed parent surveys but requested that their children not be asked. Again, similar to the parent survey, the student survey also collected information through a combination of Likert-scale values, and multiple choice and open-ended questions. The student survey was slightly shorter than the parent survey and took approximately 40 minutes to complete. Table 3.2 provides an overview of the numerical and demographic distributions of the students who completed the surveys.

Table 3.2: Demographic Distribution of Student Survey Participants

<table>
<thead>
<tr>
<th>Racial/Ethnic Identities</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade Levels</td>
<td>Grade Levels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Asian</td>
<td>2</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Black</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Mixed Race</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Native American</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>White</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>11</td>
<td>29</td>
</tr>
</tbody>
</table>

21 See Appendix B for a sample of the student survey
Parent Interviews

Following the completion of preliminary surveys, detailed interviews were conducted with individual parents and students. Parents were selected through a combined process of purposeful and snowball sampling in order to ensure a pool of interviewees demonstrating diversity across race, ethnicity, social class, child’s schooling, and perceptions about importance of their child’s participation in STEM. Based on the above criteria, I requested 26 parents (11 fathers and 15 mothers); all but one agreed. In addition three more parents (all mothers) expressed interest in participating, yielding a total of 28 parents (10 fathers and 18 mothers). It is worth noting that in several cases, both parents of individual children were intentionally included in order to collect their comparative perspectives and conduct a deeper investigation.

The parents’ interview protocol was created by using semi-structured questions so as to enable a deep exploration of parents’ individual accounts and attributions (Creswell, 2004). Parent interviews focused on the range and variation of resources used by them for supporting their children; the impact as perceived by parents, and the parents’ understanding about their children’s reactions; sources of information; and parents’ self-identification impactful or missing resources within their support. Several interviews were preceded or followed by informal conversations between researcher and interviewees; these were conducted either at the ASE site or external locations during

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22 One father declined invitation because of personal time constraints
23 See Appendix C for a sample of the parent interview
events organized by ASE program. Table 3.3 provides demographics of participants in parent interviews and focus groups.

Table 3.3: Demographic Distribution of Parent Interview Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Education</th>
<th>Occupation</th>
<th>Racial/Ethnic Identity</th>
<th>Gender of Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abigail</td>
<td>F</td>
<td>Associate</td>
<td>Research Assistant</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Bethany</td>
<td>F</td>
<td>High School</td>
<td>Crossing Guard</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Bob</td>
<td>M</td>
<td>Incompl. HS</td>
<td>Hospital Staff</td>
<td>Asian</td>
<td>M</td>
</tr>
<tr>
<td>Carlina</td>
<td>F</td>
<td>Incompl. HS</td>
<td>Custodian</td>
<td>Hispanic</td>
<td>M</td>
</tr>
<tr>
<td>Cheri</td>
<td>F</td>
<td>NA</td>
<td>Teacher aide</td>
<td>Mixed Race</td>
<td>M</td>
</tr>
<tr>
<td>Cliff</td>
<td>M</td>
<td>NA</td>
<td>Farmer</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Connie</td>
<td>F</td>
<td>High School</td>
<td>Truck driver</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Debbie</td>
<td>F</td>
<td>Bachelors</td>
<td>Programmer</td>
<td>Asian</td>
<td>M</td>
</tr>
<tr>
<td>Floyd</td>
<td>M</td>
<td>High School</td>
<td>Baggage Handler</td>
<td>Black</td>
<td>F</td>
</tr>
<tr>
<td>Janey</td>
<td>F</td>
<td>Masters</td>
<td>Engineer</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>Jethro</td>
<td>M</td>
<td>Bachelors</td>
<td>Sfw. Designer</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>Joe</td>
<td>M</td>
<td>Masters</td>
<td>Teacher</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Keri</td>
<td>F</td>
<td>NA</td>
<td>Day care Provider</td>
<td>Asian</td>
<td>M</td>
</tr>
<tr>
<td>Laketch</td>
<td>F</td>
<td>Associate</td>
<td>Clerical assist.</td>
<td>Black</td>
<td>F</td>
</tr>
<tr>
<td>Lori</td>
<td>F</td>
<td>Bachelors</td>
<td>NA</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>Marcia</td>
<td>F</td>
<td>Masters</td>
<td>Environmentalist</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>Martin</td>
<td>M</td>
<td>Some graduate work</td>
<td>Engineer</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>Mary Ellen</td>
<td>F</td>
<td>High School</td>
<td>Retail clerk</td>
<td>Black</td>
<td>F</td>
</tr>
<tr>
<td>Moira</td>
<td>F</td>
<td>Bachelors</td>
<td>Stay at home mother</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Olive</td>
<td>F</td>
<td>Associate</td>
<td>Dispatch clerk</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>Reagan</td>
<td>M</td>
<td>GED</td>
<td>mechanic</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Ruthie</td>
<td>F</td>
<td>High School</td>
<td>Day care provider</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Steve</td>
<td>M</td>
<td>Bachelors</td>
<td>School librarian</td>
<td>Mixed Race</td>
<td>M</td>
</tr>
<tr>
<td>Stockton</td>
<td>M</td>
<td>Doctorate</td>
<td>Researcher</td>
<td>Asian</td>
<td>F</td>
</tr>
<tr>
<td>Teri</td>
<td>F</td>
<td>NA</td>
<td>Office secretary</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>Tonda</td>
<td>F</td>
<td>Masters</td>
<td>School Counselor</td>
<td>Black</td>
<td>F</td>
</tr>
<tr>
<td>Trudy</td>
<td>F</td>
<td>Bachelors</td>
<td>Museum coordinator</td>
<td>Native American</td>
<td>M</td>
</tr>
<tr>
<td>Wolff</td>
<td>M</td>
<td>Bachelors</td>
<td>Graphic Designer</td>
<td>Hispanic</td>
<td>M</td>
</tr>
</tbody>
</table>

F=10; M=18

Pseudonyms have been used throughout the dissertation in order to protect the identities of parents and students participating in this study.
Interviews were staggered over a period of four months, February through May, 2010, and were held at the ASE site, participants’ residences, public library, or nearby coffee shops. Most interviews lasted about 50 minutes; in order to gather parents’ critical insights, the researcher used a few probes of a repetitive nature. All interviews were recorded digitally and transcribed. I took detailed notes, and then typed them within a few days of each interview in order to record personal impressions within the immediacy of each interview (Creswell, 2004).

Student Interviews

Student surveys were also followed up by detailed interviews with individual students. Since the key purpose of interviewing students for this dissertation research was to use insights shared by students as an additional source of data to possibly illuminate data collected from parents by affirming or refuting it, I especially solicited children whose parents belonged to the interviewee pool (Maxwell, 2005). All but one of the invited students participated in this second phase of data collection.

Student interviews were focused on collecting boys’ and girls’ perceptions regarding the personal importance of STEM fields; examples of resources used by their parents; perceived impact of the support provided by the parents; and any outstanding recollections. A total of 19 students; 10 boys and 9 girls were interviewed; most interviews lasted about 40 minutes. A majority of the interviews were conducted at the ASE site before or after the program’s scheduled events; a few interviews took place at students’ homes. All interviews and field were recorded digitally and transcribed.

25 See Appendix D for a sample of the student interview
Parent Focus Groups

The next and final stage of data collection included focus groups among a further selected group of parents. The focus groups provided a “flexible, efficient, and collaborative approach” (Szarkowicz, 2005, p. 210) for recording comparative perspectives of fathers and mothers with children of same gender, and of fathers and mothers with children of different genders. The questions for the focus groups were developed using a list of themes based on the surveys and interviews conducted among parents and students, and also new themes that had emerged within the participants’ responses collected thus far. As such, pre-selected themes served as guide-posts in establishing the initial set(s) of questions, and the emergent themes were reflected in newly developed questions (Fern, 2001). Additionally, I invited all parents to think about various kinds of resources utilized by them and develop informal lists that could be shared with other attendees of the focus groups. It was suggested to focus group participants that if possible, they bring any artifacts to the focus groups for sharing with co-participants and researcher. At each focus group meeting, about half of the attendees brought a tangible resource with them; several discussed their shared specimen in detail with other participants and researcher.

The semi-structured format of the focus groups had two goals: First, it allowed parents to identify their individual “ways of knowing and believing, as well as ways of acting and interacting” (Gee, 1999, p. 86) within context of supporting children’s entry into the STEM pipeline. Second, it provided an opportunity for collecting parents’ perspectives about the usefulness of examples shared by other parents. The second

26 See Appendix E for a sample of the parent focus group
aspect led to several discussions among participating parents, and often proceeded without this researcher's moderation of some lively exchanges among the participants.

On the bases of information revealed within surveys and interviews, I made attempts to group parents from diverse backgrounds who exhibited commonalities in their conceptualizations of supporting and preparing their children for the STEM pipeline. However, two focus groups had to be organized by practical concerns of availability, car pools, and geographical locations (Szarkowicz, 2005). Four groups with 4-5 people in each were organized in order to provide intimate proximity with co-participants and unrestrained opportunities for candid sharing of individual perspectives (Fern, 2001; Szarkowicz, 2005). Focus groups were conducted from May through July, 2010; two were held at the ASE site right after conclusion of program-sponsored events, and one each at a nearby coffee shop and the conference room of a local library.

The focus groups provided opportunities to further explore themes that became apparent during interviews, conduct member-check about researcher’s tentative conclusions, and ask clarifying questions. Conducting the focus group discussions as closing elements of the data collection process also allowed me to pose questions based on comparative responses gathered from parents and students during the earlier phases of data collection (Fern, 2001). The researcher acted as moderator for all four focus groups. At the start of each focus group, I began by introducing participants to each other (though many were already acquainted through numerous prior interactions), and followed by clear explanations and expectations for the focus group sessions, and closed each session by thanking all participants for their contributions.
As mentioned earlier, many parents brought in artifacts; these included various forms of documentation obtained from OST programs, literature sent by guidance counselors, newspaper clippings, downloads from websites, college brochures, and copies of email exchanges with OST mentors and school personnel. Still others brought in tangible things such as garage tools or art supplies. Three parents shared additional information and corroborating artifacts with the researcher two weeks after conclusion of the focus groups.

Minutes from all four focus groups were digitally recorded and transcribed. I took notes during three sessions; however, was unable to find appropriate time for taking notes during the second session. I had anticipated that each session would last about 60 minutes; however, all except one, lasted for about 90 minutes, primarily because of participants' deep interest in extending the conversations beyond specific needs of this research. Majority of participants arrived on time and stayed for the entire duration of each session. In one session, only two people attended.

To summarize, the data collection instruments: surveys among parents and students generated 754 and 452 data-points respectively. Combined together, the parents’ interviews and focus groups, the students’ interviews, and the researcher’s field notes yielded approximately 51 hours of audio-recordings all of which were transcribed and resulted into 302 single spaced sheets of Word Documents.

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27 See also, page 23
Coding and Data Analysis

Lareau (1996) posits that “the strength of qualitative data is that it can illuminate the meaning of events” (p. 224). There is consensus among several researchers that parents provide support for their children within the intertwined social complexities of personal beliefs, assumptions, and self-awareness about the importance or necessity of providing support (e.g., Eccles, 2005; Lorber, 2001; Lytton & Romney, 1991; Osborne, Simons & Collins, 2003; Prins & Willson Tosso, 2008). In order to study the resources through which parents from diverse backgrounds prepare their boys and girls for entering the STEM pipeline, it became important to uncover subjectivities of the social, economic, gendered, and cultural values assigned by these parents (Eccles, 2005; Haste, 2004; Prins & Willson Tosso, 2008).

Stake (2003) posits that understanding individuals belonging to a defined group leads to “better theorizing about a still larger collection of cases” (p. 138). Accordingly, this dissertation proceeded with a goal of unveiling the meanings assigned by parents to underlying ideas driving respective usage of efforts and resources in order to support their children’s entry in the STEM pipeline (Gee, 1999; Stake, 2003). The above approach enabled an identification of the range and variation in the support provided by parents as well as an exploration of the similarities and differences among and between parents’ and students’ individual narratives (Stake, 2003).

As also mentioned previously, the participants of this study were identified by a commonality— either as students or parents of students in the ASE program. In conducting this research, I have been cognizant that these characteristics created a uniquely qualified group of participants. Since these children had made noteworthy
advancements in the STEM pipeline at the time of conducting this research, it was highly plausible that their parents could share distinctive insights. These distinctions offered a dynamic opportunity to investigate the efforts and underlying decisions of parents whose children demonstrate sustained levels of success in the STEM fields.

The findings of this study are based on surveys, interviews, and focus group discussions conducted among parents, and the surveys and interviews conducted among students. Although the data collection spanned across participants of mixed-class, mixed-race, and mixed gender, the same core survey and interview protocols were used to ensure a consistent sampling. Understanding from the two overarching bodies of literature—the dynamics of the STEM pipeline and the factors influencing parental support were used to guide the generation of themes and codes.

Data analysis began simultaneously with the launch of this study in January 2010, and continued through an iterative process until October 2010 (Creswell, 2004; Maxwell, 2005). Survey data from all parent and students were combined into two Excel spreadsheets (1206 actors in total), and then, analyzed and coded likewise, revealing several similarities and differences among and between parents and students.

Constantly, the data was analyzed recursively to cross check for corroborative themes discerned among participants’ responses. After analyzing each sub-set of data, I would cycle back to the beginning. This process allowed continuous and purposeful revisitation of the cumulative data; the repeated ‘immersions’ prevented me from getting pigeon-holed into foci which became obvious at first glance (Creswell, 2004; Maxwell, 2005). During the entire duration of the coding process, I wrote memos capturing my
thoughts regarding data, in turn which, led to insights for further data analysis (Auerbach and Silverstein, 2003; Maxwell, 2005).

Auerbach and Silverstein (2003) propose a three step process for working with qualitative data—locating themes, coding data, and developing a narrative. In the first phase, parents’ and students’ surveys were used to develop preliminary themes, by organizing “groups of repeating ideas” (Auerbach and Silverstein, 2003, p. 38) that could be located “within relevant text [of] two or more research participants” (p. 54). Simultaneously, data gathered from parent and student surveys was used to create a contextual background for the participants’ collective perspectives.

In describing the parents’ efforts and attributions, I have been attentive to recommendations for conducting qualitative research provided by Maxwell (2005) and Gee (1999). Maxwell (2005) refers to validity of a qualitative research as the credibility of description of interactions or actions. Gee (1999) posits four levels of criteria for establishing validity—convergence, agreement, linguistic details, and coverage. Convergence is identified as the compatibility of findings to the research questions; agreement as the concurrence between findings of the study with extant research; linguistic details as the use of words and grammar to emphasize actions, and lastly coverage as the generalizability of the study (Gee, 1999). It is understood that the sample size of this study place limitations on claims of generalizability.

I made combined use of One Note and Mind Mapper software tools for tagging and categorizing all data obtained from interviews and focus groups. One Note was used to create tags and categories. In the first round of analysis, the categories included: resources used by parents at home, in-school and out-of-school; parents’ and students’
perceptions regarding the importance of STEM; indicators pointing to parents’ involvement during early, middle, and high school years; parents’ self-identification of their parenting styles and challenges of parenting; parents’ responses to challenging circumstances within the context of supporting their children; changes in parents’ decisions and any explanations; parental input on academic decisions such as choice of schools and course selection; sources of parents’ information; and students’ perceptions regarding resources found meaningful. Categories added later during the data analysis process included parents’ establishment of connections with OST sites; parents’ relationship building with OST mentors and other individuals within their social networks; parents’ actions related to their perceptions regarding children’s peer networks; and students’ responses to various sources of information used by parents.

Following this, I used Mind Mapper to organize all tags and categories into a concept map, and then, inserted links to corroborating data, which was then used as a constant guidepost during the data analysis. Finally, I developed broader themes by interweaving the stories of individual participants with emerging insights and constantly comparing these to extant theoretical constructs (Gee, 1999; Stake, 2003). Within my focus on unraveling stories shared by parents, I looked for intersections between research on parent support and characteristics of STEM entrants. As the themes started gaining coherence, it became feasible to locate areas of general agreement emerging across multiple participants’ accounts and also make note of the controversies emerging within individual narratives (Gee, 1999; Lincoln & Guba, 2000; Maxwell, 2005). I focused extensively on investigating individual narratives so as to provide meanings about how parents and their children make sense of various options.
and decisions. Through the above explicated process, I selected themes that were useful for capturing critical moments and also some noteworthy conclusions of the study (Lincoln & Guba, 2000).

In addition, I paid close attention to the emerging evidence within the individual accounts of the parents and students by using them:

to assemble situated meanings about what activity or activities are going on, composed of what specific actions...using clues to assemble situated meanings about what identities and relationships are relevant to the interaction, with their concomitant attitudes, values, ways of feeling, ways of knowing and believing, as well as ways of acting and interacting. (Gee, 1999, p. 86)

More specifically, I attempted to uncover the implicit meanings of the parents' individual actions and attributions, the ones that were “not openly, directly, completely or precisely asserted” (van Dijk, 2001, p. 104).
Part III: Limitations and Procedural Challenges

All research studies, irrespective of how much deliberation and care goes into their planning and execution, are accompanied by at least some challenges (Creswell, 2004). And this dissertation was no exception. Three kinds of concerns were experienced in this dissertation—generalizability, procedural challenges posed by logistical details, and identification of researcher's role and biases (Creswell, 2004; Maxwell, 2005). In terms of generalizability, though, it is near impossible to ensure objectivity within a qualitative study; I attempted to mitigate these limitations by collecting multiple sources of information from individual participants and by including participants from diverse backgrounds (Maxwell, 2005).

I believe that inclusion of comparative accounts from parents and their children, and then, cross analyzing their respective insights, strengthened the findings of this study (Maxwell, 2005). Although in the very early phases of my research, I was remiss in not referring to field notes on constant bases; however, I corrected this oversight after receiving advice from my dissertation committee chairperson. I believe that triangulation of different sources of data collected from each participant prevented inclusion of systematic biases, and as a result allowed for presentation of themes that were most demonstrative of the study sample (Maxwell, 2005).

The selected site was one of three potential sites, and was decided upon after considerable scrutiny and contemplation. I could not have asked for a more viable sample population whose overwhelming enthusiasm enriched the research experience in numerous ways. As a result, only a few procedural challenges were experienced during
the entire seven and half months of this research study. One layer of concerns was presented by the common affiliation of participants—with the ASE program—either as parents or students. It is possible that many of the insights shared by study participants may have been constructed in each other's proximity over the last few years. Therefore, their accounts of earlier years might not be truly reflective of their self-actions; rather, these might have been overstated or undergone modifications as a result of each other's influence.

Another area of concern surfaced during the organization of focus groups, as a result of prior relationships among several participants. I had intended to group parents based on definitive criteria, but was not always possible because several participants indicated desires to attend focus groups along with acquaintances (parents of children's friends, from same neighborhood, carpool etc.). The close ties among some parents, led to inadvertent revelations of personal details that threatened their anonymity as well as of others. Therefore, in a few instances, before processing the audio recordings for transcription, I had to delete some sections. It is possible that selective deletion of audio recordings may have excluded pertinent accounts which could have directed the research findings differently. I made attempts to insert compensatory elements by comparing tentative conclusions with additional data obtained from informal conversations and field notes.

Initially, I had identified the racial/ethnic identities of the participants as following: African American, Asian, Caucasian, Hispanic, Mixed Race, and Native American. Following the decision, I conducted a member check; several participants who were likely to be identified as African American and Caucasian, protested and instead
indicated preferences for being identified as Black and White respectively. A person of mixed race preferred being identified as White. Other participants were agreeable to these requests, and therefore, changes were made accordingly. As a result, the following categories have been used in this dissertation: Asian, Black, Hispanic, Mixed Race, Native American, and White.

Personal relationships with participants can sometimes confound the validity of research (Maxwell, 2005). Prior to launching this research study, my interactions with ASE had been limited to the mentors with whom I had developed strong relationships. In the beginning, I was concerned that these relationships might result into exertion of undue pressure on students and parents regarding participation in the research study. Fortunately, that concern dissipated soon; after the initial introductions between researcher and potential participants, the mentors mostly refrained from any other conversations about the research study. Furthermore, aside from a few negotiations related to issues of scheduling, I did not discern any explicit signs of unwillingness among the study participants. As mentioned earlier, the initial responses of potential participants were overwhelmingly positive.

Maxwell (2005) posits that a qualitative research should focus on “understanding how a particular researcher’s values and expectations influence the conduct and conclusions of the study” (p. 108). Using Maxwell’s recommendations, I made diligent efforts to include my developing ideas and quandaries in field notes, and then, ascertain whether or not they were coalescing with the research study. My dual identity as a researcher of STEM education as well as a parent of children interested in pursuing

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28 At a later stage of the research, this person switched preference
STEM fields, created quandaries of two kinds, both of which become apparent during earlier phases of the study. Once the parents became aware of my dual status as a researcher and a parent, often, they attempted to seek my affirmation regarding resources used by them to provide support for their boys and girls. I made sincere attempts to refrain from directly responding to inquiries or challenging any of their assumptions, and instead sought clarification from parents by posing additional questions. However, in two instances, when it became apparent that the parents' decisions were based on some misconceptions, I found myself mired in profound dilemma. On the one hand, pointing out these parents' misunderstandings had the potential of withholding potentially discrepant variables from the research; on the other hand, I felt ethically responsible for sharing my knowledge of extant research. After some contemplation, I was convinced that the latter choice was the 'right' one.  

Summary

The essential goal of this study was to understand and describe the various resources employed by parents in order to support their boys and girls towards pursuing opportunities in the STEM pipeline. Accordingly, qualitative research methods were most suited for exploring the questions guiding this dissertation. By utilizing principles of a case study and qualitative research methods to uncover the meanings behind parents' actions and attributions, this study captured recurring themes and emerging conclusions representing the study participants' commonalities, as well as the specifics distinguishing individual narratives. The sample size, diverse characteristics of participants, and

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29 Details of the exchange with this parent are included in a later chapter
multiple modes of data collection are likely to strengthen the findings of this study. The dual attention towards situating the findings of this study within extant research and explicating the emergent specificities has created an insightful context that may guide future research studies related to parents’ role in furthering their children’s progress within the STEM pipeline.
CHAPTER FOUR: FOSTERING STEM READINESS SKILLS

Introduction

Within their quest to unravel factors that are responsible for creating leaks in the STEM pipeline, researchers posit that successful entry in STEM fields is no different than success in several other disciplines which are similarly identified by accompaniment of unique skills and abilities (e.g., Greenfield, 1996; Hill Corbett, & Rose, 2010; National Research Council, 2007; Simpkins, Davis-Kean, & Eccles, 2006; Webb, Lubinski, & Benbow, 2007; Zeldin, Britner, & Pajares, 2008).

A thorough analysis of all data sources reveals that parents in this study emphasize ongoing development of several basic skills as well as some specific ones; parents’ attributions are supported by a near unanimous agreement among their boys and girls. My research revealed three distinct groups of skills characterizing these parents’ efforts: mathematically oriented abilities, guided inquiry processes, and foundations of teamwork. In the following sections, I discuss each group in detail, first, within the parents’ narratives, and then, identify areas of possible concurrence among the boys and girls. Throughout the chapter, I have also focused on how the respective insights of parents and children align or digress from extant research.

More than half of these parents emphasize appreciation and comprehension of mathematical skills through multi-faceted activities, followed by several parents making attempts to instill habits of inquiry and experimentation among their children. Finally, a rather small number of parents acknowledge efforts towards introduction of teamwork to their children. Within parents’ efforts targeted towards developing and enhancing
mathematical abilities, the emphases on spatial skills stand out noticeably and also among the largest numbers. More than three fourths of parents, whose efforts emphasize mathematical abilities, demonstrate focused attention on the advancement of spatial skills among children.

**Bases of Successful Entry in STEM Fields**

Sol Garfunkel, a well-known mathematics educator, has long stressed the importance of strong foundations in mathematics, insisting that the nation’s objectives of creating success in emerging technologies and occupations will require students to become fluent in mathematical reasoning, and gain proficiencies in mathematical concepts and procedural skills (see also, National Mathematics Advisory Panel, 2008). On a more generalized level, the common yardstick for success in all STEM fields includes skills of problem-solving; theorizing, testing, and analyzing hypotheses; innovation; mastery of new and emerging technologies; and spatial abilities (Hill, Corbett, & Rose, 2010; President’s Council of Advisors on Science and Technology, 2010; National Mathematics Advisory Panel, 2008; National Research Council, 2007; President’s Council of Advisors on Science and Technology, 2010; Schleicher, 2010; Simpkins, Davis-Kean, & Eccles, 2006; US Department of Education, 2008).

Skills that are relevant for learning mathematics include: fluency in carrying out computations; application of mathematical concepts; abilities to formulate, represent, and convert numerical values; use of numerical evidence to reason, analyze and explain happenings (Hill, Corbett, & Rose, 2010; National Mathematics Advisory Panel, 2008).

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Among these, spatial abilities are garnering attention of increasing numbers of researchers and educators, many of whom claim that spatial skills may be the ultimate clue providing insight into the differentiated levels of success in STEM fields (e.g., Ceci & Williams, 2009; Hill, Corbett, & Rose, 2010; Newcombe, 2010; Turziel, & Egozi, 2010; Wai, Lubinski, & Benbow, 2009; Webb, Lubinski, & Benbow, 2007).

Additionally, dispositions such as persistence and continued practice, and experiential learning opportunities are understood to be effective means leading to enhanced mathematical abilities (National Mathematics Advisory Panel, 2008).

Likewise, skills relevant to the learning of science include: ability to apply and interpret scientific knowledge; generate and evaluate scientific evidence; and ability to offer clear explanations of scientific processes (National Academy of Sciences, 2009; Schleicher, 2010). Relatively less information is available regarding requisites of engineering and technology, although a few researchers have identified the capacity to reformulate existing applications of technology and engineering among successful students of STEM fields (Hill Corbett, & Rose, 2010; Katehi, Peterson, & Feder, 2009).

Recurring Emphases on Mathematical Abilities within Parents’ Efforts

Within this study, the importance of encouraging their children to do well in mathematics was clearly apparent among parents whose educational and occupational backgrounds would be logically suggestive of such inclinations, and also among parents whose demographic profiles would not be inherently indicative of such awareness. Slightly less than one half of total numbers of parents revealed efforts emphasizing inculcation of mathematical abilities and dispositions among their children. These
parents identified specific efforts towards fostering appreciation for mathematics among their boys and girls. The common manifestation of similarly directed efforts among a large number of participant parents can be understood by examining insights collected from two fathers, one of a daughter, the other a son.

Reagan is father of a 17-year-old daughter who attends a charter school located about 13 miles from the ASE site. He works as a mechanic at a garage attached to a gas station. Scheduling an interview with him was fraught with several challenges; twice he canceled at the last minute because of emergency repair jobs. However, after arriving on the interview day, things proceeded smoothly, and he even disregarded the cell phone’s loud ringing on two occasions. Martin works as a supervisor at a large-sized engineering firm under the auspices of a Fortune 500 corporation, where his job includes recruitment and training of new employees. Martin attended a well-known school of engineering as an undergraduate, and followed up with graduate coursework in management. His 16 year old son, Chris, has participated in the ASE program for past one year.

In response to the parent survey which sought information about parents’ perceptions regarding importance of providing support for children within STEM fields, both Reagan and Martin indicated their views about importance of helping their children succeed in STEM at high end of the Likert scale. Similarly, both parents indicated that they perceived their child’s interest in pursuing STEM fields at the high end of the spectrum. Their respective responses regarding the importance of helping their children succeed in STEM and the level of their children’s interest in STEM were aligned with opinions of more than half of all parents who completed the preliminary surveys.
Likewise, the interviews with each father proceeded quite similarly in the beginning, though; some clear differences became apparent later in the process:

Reagan: Yous need math for engineering. Yous need math for science. If you are in any engineering you has to have math. So that’s how they are tied together. Math is key to any science ...technology or...you know what, I don’t know how else to describe it. They all just relate to each other. You have to have one to have the other. You can’t have science without math. The way I see it, you can have math by itself but you can’t have science or even engineering without math.

When I met Martin, he had just arrived straight from work to the ASE site. Compare the comments made by Martin to Reagan’s reflections:

Martin: If you can do Math and Engineering, you can do anything. I think it is the basis of everything. Because you can figure any problem or task, it makes you more analytical and you can figure out any problem you can come up with. If can analyze it, no matter what it is, you can determine it. And I think that with math, you can determine the steps of how to do engineering and technology. It (math) gives you building blocks on how to achieve certain problems. All problems, I think are rooted in the understanding of math.

Further probing by this researcher revealed more similarities between Reagan’s and Martin’s respective reflections:

Reagan: At the garage where I work, I asked the owners if they would let her (daughter) run the register, organize the store, the shelves, the products that we were selling. Label products to sell and handle customers. That sort of thing. When she started, she would ask questions. If the cash machine did not work, she learned to add by her fingers...now she does the counting in her head. No fingers or paper. Just like that.

Martin: We put the 100 board pieces of puzzle on the floor, you know. Plus he built Legos and he was very inquisitive. Also, I build things at home and he would always want me to help him when I picked small projects around the house. Most were related to my hobbies of making things for my nieces or other relatives... I would build tables and little chairs, shelves, and everything. As a little a kid, he always helped. He always wanted to help. Now he has progressed into electrical work. I do electrical work and plumbing at home. I recently put a filtering system in. He helped me designed it.
Later on, Martin explained his efforts in more detail:

R: What do you think is the benefit of having your son work along with you while you are taking care of these home repairs?

Martin: Well, I see it this way, Chris, he looks at things more, not verbally, but he likes to think about things. You can talk to him about science, technology, engineering, and math and he’ll just sit there and dwell on it and a week later say, “Yeah, I want to be an engineer.” But if gets to tinker around with me, he can how see it’s done, what’s done, how to do it, why to do it...that sort of stuff. You can never get that in a physics class.

R: So you hope to teach your son by demonstrating it on a practical level?

Martin: Yes of course. I mean yes...I feel that this might just keep him interested in science but also let him realize that a lot of hard repeating kind of hard work goes with this. That’ what I am hoping to do. For him to understand that being in science or engineering is not just about fun. It’s like, indirectly, I am saying to him that being in science or engineering is about attention to details. To working on details that require careful measuring. That’s all.

In contrast to Reagan’s acknowledgement regarding limited prior experiences of using mathematics for personal use, Martin revealed his personal struggles and perseverance to emphasize that mathematically oriented skills and dispositions can be developed through hard work:

Martin: He always felt that one had to be, you had to be perfect in math. The other day, he went on and on, but maybe wasn’t sure on some of things they were doing in class. I think my examples helped him, that it helped him immensely.

R: To do what?

Martin: For his math skills, as far geometry and algebra and it helped him to know that because I was terrible at math. I got better, and I am now an engineer

R: Do you tell him that? That you were terrible at math?
Martin: Yeah.

R: What did he say to that?
Martin: He’d say, “nay, you weren’t dad!” And I say, “ah, yeah.” He said, “Yeah but still... I don’t have the background.” I told him that “you can learn by practicing.” That helped him a lot. A lot I would say.
R: So what is the difference that you are seeing now?

Martin: Because he would get very frustrated if he didn’t have 100’s on his tests. If he couldn’t do a specific problem, he would get all upset. He’d cry, or he’d act out. Now he is seeing that getting frustrated does not help. But what helps is working on it. That makes a huge big difference. Oh yeah. I think he’s doing a lot better. A lot better.

Martin: We pushed the Legos as an example: Know you, he would build stuff. He’d be 4 years old and he’d be building stuff that would be 8 year old, or 10 year old kid would be doing. So we always emphasized that. Practice. Practice. Work hard. Be good in math. And now the light bulb finally hit. Actually, I think that it started just this last year. I think the robotics had a big thing, a major influence on him, I believe. I mean his motivation for engineering.

R: Oh yeah? In what way?

Martin: Once he started seeing how they build these things and how you learn about different designs and how you can do gear ratios to determine speed and power and things like that. I think that really helped him realize that “you know, maybe I want to be an engineer” because he sees in it a finished product, you know, how wonderful it is. It’s a learning experience as you go, but like I say, you see a product that is completed, then, it is fun too.

Intrigued by close similarities within their respective insights despite extensive differences in educational and occupational backgrounds, I invited Martin and Reagan to attend the same focus group. As also explained in Chapter three, focus group participants were requested to bring a tangible resource which they had used with their children, share information about how the resource was used, and any ensuing impact witnessed by them. In response, Reagan brought illegibly printed cash receipts with numerous pen
markings, and Martin shared the blue-print of a filtering system with several hand-written computations on each side.

The following excerpts highlight the exchange between Reagan and Martin during the focus group:

Reagan: I brang with me a receipt from the cash register which my daughter used for her summer job. On the day it printed like this, it [cash register] was not working good.

Martin: I have here a sketch that I had made of the filtering system that I installed a few months ago. You will notice some calculations on the side that were done by my son, Christopher... Chris we call him.

Reagan: The day, the [cash] machine broke, my daughter went like “ughhh ughhh what I am going to do now. This person bought four things. I don’t know how much cash to give back from a $20 bill.” So, in the evening when she tells me all this, I says, “do it yourself”

Martin: I had Chris make all these calculations some by hand and some with calculator. Before he really got into doing them, I had to push him quite a bit. I also showed him how to perform the calculations.

Reagan: After doing adding and subtracting by hand a few times, she was no longer afraid. She even has [developed] quick shorts cuts in her head. Did your son feel the same way?

Martin: Yes, but in a different way. First, he was reluctant too; especially because he felt “why do it, when I can use the calculator.” But I would push and ask him to try. The biggest benefit was that by repeating such calculations a few times, he was able to understand decimals much more easily than he had before.

Reagan: I have heard my daughter says “decimals are like pennies.”

Martin: Hmmm... I will check to see if my son understands that comparison. Am sure he does, but I will bring it up. To check if he does.

Careful analysis of Reagan’s and Martin’s evolving accounts reveal that despite the demographic differences between them, there are striking commonalities in their
respective understandings and subsequent interventions within facilitation of children’s education. The above excerpts are indicative of the underlying similarities in these parents’ strong beliefs about the importance of conducting quick mathematical computations, problem solving, and numerical conversions. Finally, Reagan’s and Martin’s accounts emphasize utilization of everyday routines to facilitate development of mathematical skills, which further, according to both parents have been responsible for increasing their children’s confidence in mathematics.

In spite of a marked difference in the language utilized by both parents to explicate their respective views, a distinguishing attribute is the evenness with which they emphasize the importance of learning mathematics for their children, almost, as a necessary first-step for the learning of mathematics and science. In addition, both, Reagan and Martin demonstrate either an intuitive or informed grasp of the fundamental relationships between mathematical proficiencies and success in other STEM fields. Both use problem solving and computational skills for promoting their children’s learning. And although the means employed by each parent are strikingly different, effectively, the goals of establishing a format for practicing quantitative skills are quite similar. In Martin’s words: “And by learning through these [processes] he sees that he is a lot smarter than he thinks he is and it builds up his confidence. Even if his grades are not reflecting that all the time, I know he is doing and practicing math.”

Although some core similarities can be discerned within the individual narratives shared by Reagan and Martin, their individual accounts also speak to some key differences. On the one hand, Reagan uses rudimentary mathematical skills such as computation and numerical conversions, Martin moves into deeper attributes of abstract
thinking, theorizing, and hypothesizing. The variation witnessed between Reagan and Martin is possibly indicative of the corresponding differences in their educational and professional backgrounds. Each parent has optimized their prior knowledge and experiences within usage of providing effective learning experiences for their daughter and son respectively. The resources through which Reagan and Martin provide support for their children are also widely discrepant. One can see that Reagan uses the real-world scenario of an automobile repair garage to help his daughter practice math skills, while Martin uses a broader array of affordances—puzzles, Legos, and personal hobbies to enable his son to develop intimate familiarity with mathematical skills. Their attributions speak to issues of privilege and access to opportunities and resources based upon social class differences.

The exchange of ideas between Reagan and Martin reveals another noteworthy aspect. It becomes obvious that these parents are not only engaged in providing usable and transferable ideas to each other; in addition they are building upon each other’s ideas. Martin is seen providing explanations of using Legos to further skills of problem solving and analysis. In turn, Reagan shares an analogy demonstrating the relationship of mathematical parts to whole by using pennies and dollars as an example. Furthermore, it is important to point that beyond demonstrating a deep appreciation for the development of mathematical skills, Reagan’s and Martin’s attributions demonstrate close alignment with emergent research regarding the use of appropriate strategies for reinforcing mathematical skills among boys and girls.

Throughout the study it was not uncommon to find more parents like Reagan and Martin, fathers and mothers, who held similarly inclined opinions, and acted upon their
views through comparable ways by using easily accessible resources. There is, however, a significant difference; in contrast to extant research, Reagan, is seen offering support for his daughter in a manner which is comparable to support provided by a boy’s father. It is often seen that the differential motivation and capacity of girls to succeed in mathematically oriented activities is limited by parents’ perceptions and stereotypical beliefs, but clearly, not in this case. In here, Reagan’s reflections reveal his determination to provide a system of support to enhance his daughter’s confidence in problem solving, computation, and numerical conversion.

*Parents’ Understandings regarding the Scope and Sequence of Math Classes*

In addition to emphasizing the significance of developing mathematical skills, several researchers also agree on the sequential importance of mathematics at middle and high school levels—Algebra I, Geometry, Algebra II, optimally followed by Calculus (e.g., Commission on Mathematics and Science Education, 2009; National Mathematics Advisory Panel, 2008).

In clear conformity with extant research, several students in this study attributed their superior performance in mathematics to their parents’ encouragement and constant reminders. Some students recalled an almost relentless push by their parents toward pursuing higher levels math courses during middle and high school years. For example, the following exchange between the researcher and Ford, a junior in a public high school, exemplifies six students’ acknowledgement of their parents’ efforts toward following carefully planned sequence of math courses:
R: What kind of classes do you want to take in the senior year?

Ford: Definitely BC Calc. maybe physics also. And material sciences which is an independent study shop class.

R: So you are really going to load up on math and science?

Ford: Oh yeah, I have come to love math and science now. I used to not want to take hard classes in Math.

R: What made the change happen?

Ford: My stepdad has been after my life for so long about not quitting in math. He pushed me and pushed me. If it wasn’t for him, or actually for his constant, constant talking, I would be still taking intro to Algebra (Algebra Part I) in junior year. I could have said good bye to going to study engineering at votech-school.

R: What are your current feelings about being ‘pushed’ by your stepdad?

Ford: I guess I will have to live with that ...you know I mean his ...his nagging for the rest of my life. I am sure one of these days, he will remind me but that’s ok, that’s better than not being able to go to the right school.

Both Ford and his stepfather are likely to be encouraged by extant research that identifies low enrollment rates in higher level mathematics courses during high school as one of the crucial reasons behind the declining numbers of students transitioning into STEM degrees. Although Ford confesses not appreciating his stepfather’s “unending nagging” or the fact that he “will have to live with the reminders for a long time,” it becomes apparent that he recognizes the benefits of adhering to his stepfather’s advice. Furthermore, Ford identifies a direct relationship between the sequence of math courses and his future prospects of matriculating into engineering schools.
Spatial Skills

There is lack of irrefutable evidence to support some researchers’ arguments that spatial skills are a prerequisite for obtaining successful entry into STEM fields; however, increasingly several teacher educators and researchers posit that spatial skills be viewed as a cornerstone competency (e.g., Ceci & Willaimes, 2009; Newcombe, 2010; Webb, R. M., Lubinski, D., & Benbow, 2007; Wai, Lubinski, & Benbow, 2009). Additionally, barring a few minor differences, recent studies have found spatial skills can be enhanced in both genders (e.g., Newcombe, 2010; Sinnes, 2006; Spelke, 2005; Sorby, 2009; Tzuriel & Egozi, 2010). The emergent understanding is lending a more positive outlook to the role of spatial skills in broadening the STEM pipeline.

Within the context of extant research, it is noteworthy that in this study, overwhelming emphasis on development of spatial skills has emerged as a critical attribute among three-fifths of all parents. Not surprisingly, during the entire duration of this study, none of the participants—parents or students—used the term ‘spatial skills’ in their interactions with this researcher or among themselves in presence of researcher. Approximately one third of all parents demonstrated either acquired or intuitive understanding of spatial skills; these were apparent within parents’ efforts to facilitate the development of mechanical and abstract reasoning and geometric visualization in their children. Surprisingly, an unmistakable acknowledgement of spatial skills was discerned within students’ attributions also. More surprisingly, girls as well as boys recalled their parents’ efforts in this direction, albeit, more explicitly by boys than girls.

My interview with Maxine, a 10th grader who attends a single gender parochial school, took place at the ASE site. She was dropped off by her mother an hour before the
scheduled program began to ensure time for a relaxed conversation. The interview took several interesting directions, and as a result extended slightly beyond the anticipated 60 minutes.

Maxine: I enjoy working, like I actually using the tools and building something and knowing what you are building. It is actually fun to compete and possible win in car races.

R: Ahh, so we have a NASCAR fan.

Maxine: Yep, yep, me and my dad

R: What else do you do with your dad?

Maxine: I live on a farm, so when my dad was building one of those little sheds, I helped him build the shed. Before that I helped him put up the fences. He would ask me to rotate half way to him or sometimes it was more complicated. Let me see if I can remember, one time, he said “imagine you are standing at 3 on the clock and now, you have to move the wrench to 7 on the clock.” Can you believe it! I remember messing up but every Sunday there he was with his tools and needing to fix something or the other, and so there I was alongside him. So I've always been around helping him, then once in while fixing small things by myself. Now I just helped the team build the “kicker” (a key component on the robotic machine).

In the above exchange, Maxine is referring to her understanding and application of rotation, one of the more complex spatial skills detected at significantly higher levels among STEM entrants. It was apparent that Maxine’s father, Cliff, had incorporated the above activities, unaware of their significance; in hindsight he expresses satisfaction at the turn of events and the long term rewards harvested from his early efforts: “For children of a father like me who grew on a pig farm [this] makes a world of difference…My wife says that it is probably the only reason. Fortunately for us, the nuts and bolts are all that really matter, it really does.”
Cliff’s reflections resonate closely with current research claiming that informally constructed experiences of using mechanical tools can provide girls with increased confidence in pursuing educational and occupational choices perceived as more ‘masculine’. Maxine’s recollections also indicate that although spatial skills may be innate to a small number of people, they can be developed and strengthened through practice among larger numbers. Furthermore, it is possible to conclude that Maxine’s comfort with tackling complex problems in geometry in sophomore classes emerged from her close proximity with everyday tasks on a family farm. Hands-on experiences like those shared in the above section have extra significance because it is plausible that enhanced spatial skills will increase retention of girls in STEM fields.

As mentioned earlier, more boys and their parents recalled a focused attention on the development of spatial skills. The interview with Dave, a senior in high school who had just received an acceptance letter from a well-known engineering school, was very similar to Maxine’s:

Dave: I've sort of like always had an interest in building things, and my dad, I guess, sort of helped out along.

R: In what way?

Dave: So since...since like an early age, I guess I've been like--he's been--he does like projects, like down in the basement we have like a shop, and, from an early age, I've always been down there helping him. And whenever he'd be, like, changing the breaks on the car or something, I'd be out helping him, and...I don't know. Yeah, whenever I got some like crazy idea, he'd help me out with it.

R: You and your dad worked on it? In what way did he help you in figuring it out? Can you tell me what you mean by crazy ideas?

Dave: Just there—there's been this wish, I guess, since middle school, once we made a slingback in the backyard—I wanted to make a big one so it could lob boulders back into the creek so...so we did. Well not actually but we designed like
a sketch. Then we made a mini version...a smaller one. It could launch large sized pebbles but of course not boulders. So he helped me figure out the materials and the shape.

R: So you had fun sketching and planning?

Dave: Yeah. Those were good times. Oh, you want to hear another thing? You want to hear this story:

Dave: Last year I wanted to make a flamethrower. And so I was like, “Dad, I really wanna make this flamethrower.” And he, uh, he was like, “Alright, sketch up a design, and then I’ll make sure it’s safe, and we could build it.” So we built it. And, you know, it’s just like he is there...open and encouraging to my crazy ideas...anything like that.

R: How old were you when you started working in the shop downstairs?

Dave: Since I could remember. One of my earliest memories is being downstairs in my old house and not even being able to see over the workbench, but looking up at my dad, like, working on stuff.

The accounts shared by Maxine and Dave clearly indicate that both of them are deeply engaged in learning processes leading to well-developed spatial skills. Their comments are indicative of comprehending several aspects of spatial skills: rotation, measuring of angles, and use of concrete materials to construct objects. Although neither adolescent used the term ‘spatial skills’ in an explicit manner, their respective comprehension of spatial skills is distinctly visible, for example, Maxine’s understanding of rotation, and Dave’s ability to produce sketches drawn to scale. However, in contrast Maxine’s experiences regarding development of spatial skills alongside her father’s responsibilities as a farm owner, Dave’s experiences are dependent on his father’s support and encouragement.

Unmentioned in the above accounts is the cost differential, while Maxine’s informal learning is anchored within a routine necessity on a family farm, Dave’s
acquisition of spatial understandings are outcomes of resource heavy hobbies. And yet, Maxine and Dave identify very similar learning across attributes of direction, scale, and rotation. Whether through happenstance or on purpose, Maxine’s and Dave’s fathers are ahead of extant research which often claims that an overwhelming majority of youth receive inadequate exposure to spatial skills. In both instances, these children are receiving numerous opportunities allowing them to “generate, retain, retrieve, and transform well-structured visual images” (Lohman, 1994, p. 1000). The examples shared so far have pointed to the different ways through which fathers have stimulated their children’s learning processes within acquisition of spatial skills.

This research study was not able to locate any comparable situations such as the building of flame throwers among mothers along with their sons or daughters; however, there was clear evidence suggesting that several mothers understood the relevance of following procedures for constructing complex objects, and imparting the know how to children. Among them was Olive, mother of three boys; she home-schooled her oldest son but not Paul (who participated in this study) and his younger brother. She works as a dispatcher for a transportation company and occasionally helps out a local church with accounts and bookkeeping. Olive and I met on three occasions; during each interaction, our conversation focused on a different aspect of her efforts and revealed Olive’s strong opinions about the importance of working with children to develop their spatial skills:

Olive: There were many times when I would help my boys construct some project thing. We built a castle or we built a pyramid. We built a number of things that were used in their class as a part of their class projects.

Olive: I volunteered at school helping the teachers in their projects. Most didn’t want to do the messy jobs themselves but it was alright with me. I would always help them with that. I worked with them to make Halloween costumes, with
poster paper and pipe cleaners projects. I was always helping the children to draw, cut, measure.

Olive’s opinions resonate strongly among many math educators who believe that spatial skills occupy a special position because of impact on other cognitive skills such as mapping, computer gaming, and visualization. The perspectives shared by Olive demonstrate a deep understanding about the importance of construction-based activities toward enhancing spatial skills, such as measuring and calibrating scales. The above accounts identify a lack of enthusiasm for “messy jobs” related to the construction of Halloween props at her son’s school. Further, she claims these simple actions enabled her to close existing gaps at son’s school.

On another occasion, Olive informed me that when her boys were young, she provided them with arts and crafts supplies. She recalls her boys were often teased for being ‘girly’ because their “mother made them do crafts.” Nevertheless, she recognizes that tools belong to kitchens and garages. Based on the scope of the opportunity and availability of resources, she guides her sons to conduct several tasks related to development of spatial skills:

Olive: Yeah, it does strikes me as very odd because kitchens are full of tools and I learned to sew from my mother. These are all tools that women use all of the time. I don’t think they are fundamentally any different than the tools that men use in their basements. I mean there is really not that much difference between a drill and a blender; a hand mixer I guess would be a better comparison.

Once again, Olive’s perceptions are in close alignment with extant research which indicates recreational activities such as ‘playing’ with shapes, and adapting to changes in scale and measurements deepen students’ appreciation for spatial configurations. Her
actions are resonant of deep understandings about the importance of spatial configurations and the ability to adapt and reconfigure them. The development of these attributes is considered a strong harbinger of success in STEM fields, especially within physical sciences.

Development of STEM Skills through Guided Processes

Beyond providing opportunities for acquiring mathematical proficiencies, data sources in this study revealed the parents’ extensive efforts to instill skills encompassing inquiry and processes of experimentation. In general, it was seen that a slightly more than one third of the parents targeted their efforts toward this particular group of goals; within the above, most undertook their efforts within a clear recognition that such efforts would benefit their children, although a few (n = 2) lacked clarity regarding underlying processes or factors.

Inquiry

Research conducted by Frazier, Gelman, and Wellman (2009) concludes that children make expansive gains in discovery and information seeking processes when adults offer thoughtful explanations to children’s questions. Children’s conversational exchanges and the “reactions to the different types of information they get from adults in response to their own requests, confirms that young children are motivated to actively seek explanations” (Frazier et al. 2009, p. 1593).

This study identified a definitive group of parents including fathers and mothers who recalled amplifying children’s discovery of the factors leading to everyday events by
using them as opportunities to guide conceptual development of inquiry. Six fathers and eight mothers demonstrated efforts leading to facilitation of such characteristics among their children. For example, consider the following excerpt from an interview with Jethro, father of a male sophomore:

Jethro: I remember that I had this friend who is a teacher, older woman, who we used to bump into in the grocery store when Shane was younger. One day, I had him in the front the wagon, the shopping cart, and he was constantly talking to me about what I was buying and what I was choosing this one and not that one, just constant conversation or one way or whatever, So one day, she stopped me, she said, “I think it’s great the way you talk to him.” She said, “children learn by asking questions” and so I thought “she probably knows, so no harm in trying it out.”

In the above, Jethro was reminiscing about his early interactions with his son, Shane, during their daily routines of grocery shopping.

Jethro: So then, I stopped showing my irritation, even if he asked me the same question over and over again. I listened to his stories about the paper plane going down probably a hundred times. And then, later he would always ask me? “You know why? You want me to tell you why?” And I started listening.

Jethro’s actions can be more clearly understood within Chouinard’s work (2007) which postulates that interactions involving children’s simple inquiries and adults’ explanatory responses help children to make connections between different variables. In the beginning, Jethro is seen responding to his son’s repetitive questions merely to provide entertainment during the weekly errands; however, over time, he notices a move toward increased clarity as well as complexity in Shane’s questions:

Jethro: Soon I noticed that his stories were becoming smarter, they had more details. Also more details were of a believable kind instead of him telling me stories about popcorn jumping out of the jelly jar.
Jethro’s accounts reveal that as his child grew older, with support and encouragement, the questions begin to demonstrate deeper analysis and synthesis. A few parents like Reagan recall episodes from their own childhoods to identify how they acquired appreciation for the inquiry process. Further, Reagan identifies a process of transfer from the early constructive influence of an elderly neighbor in his self-attempts regarding unceasing questions posed by daughter:

Reagan: He took a liking to me because I wanted to know why. I was always asking him, “What is this for? What is that for? What are the stars there for? How they keep rotating? What keeps them there?”

Reagan: He taught me a lot of things outside of school by explaining how things work. Then he moved away.

While recognizing the positive impact of a stimulating relationship with a friendly neighbor and the subsequent intellectual void left in his life after the neighbor moved away, Reagan claims to have become mindful of what he must ensure for his daughter’s learning environment:

Reagan: Like I said, I just didn’t continue school myself. But with my daughter, I tried for it not to repeat. I tried for not to let it happen. As, like be patient with her. You know with her chitter-chatter. Sometimes, I think that she is doing things at school and [ASE] because I was patient with her non-stop questions and talking.

Previously too, Reagan had acknowledged lack of any theoretical understandings; however, his actions reveal appreciation for the iterative cycles of queries and responses. In turn, he acknowledges concerted attempts to create a stimulating learning environment for his daughter and indulge “her chitter-chatter” in the hopes that the conversational exchanges will be beneficial for stimulating her to probe and ask questions. The accounts of a few other parents demonstrated the adoption of similarly targeted efforts. In the
words of Cheri,\textsuperscript{31} mother of a 17-year-male, her willingness “to listen Anshua tell the story about the space craft diverting from its projected path for the 17\textsuperscript{th} time,” empowered her son to “want to know more and also listen to his mother’s ideas.”

\textit{Experimentation}

The National Research Council (1996) recommends that beginning from the “earliest grade levels, students should learn what constitutes evidence and be able to judge the merits or strengths of the data and information that will be used to make explanations” (p. 122). At the simplest levels, experimentation includes setting up a design by using some control variables, implementing the design, and analyzing results obtained from investigations (National Research Council, 1996, 2007; Toth, Klahr, & Chen, 2000).

In contrast to several parents’ emphases on inquiry, a smaller group of parents, comprising less than one sixth of total numbers, revealed efforts targeted towards encouraging children to develop an appreciation for experimentation. Floyd, father of a female high school senior was one of few parents who recalled efforts aligned with extant research but without any foundational knowledge about conducting experiments or importance of experimentation as an acquired skill:

Floyd: I used sit down with her to ‘play’ with all the tools in the garage or sometimes in the backyard. I have a different attitude than my brothers; they don’t want their little girls playing with tools in the garage or soap bubbles in the kitchen sink. I used to say “that’s ok with me”. Back then, we did not know these terms like STEM or whatever else, back then we only knew simple things. But I do remember thinking, saying to them...to my brothers, “if that helps her like science or just be smart at school then that’s fine with me.”

\textsuperscript{31}Chapter V discusses Cheri’s interactions with her son in detail
In the above, Floyd is witnessed sharing memories of ‘letting’ his daughter delve into simple experiments at home. Floyd’s attempts to encourage his daughter’s playful exploration with the mechanical tools in his garage can be recognized as examples of impromptu opportunities that emerge within everyday routines. However, his actions are noteworthy because of three essential aspects: 1) Floyd is comfortable in initiating the play based activities with a female child; 2) Floyd is cognizant that his actions are atypical of his generation or male siblings; and 3) his actions are simultaneously indicative of direct intervention as well as non-participant guidance. Remarkably, Floyd, neither whose current occupation nor past experiences are indicative of knowledge about STEM fields, in addition to self-acknowledgement about lacking explicit understandings, his efforts demonstrate close alignment with extant research. Similarly, during the multiple interactions with Olive, I could discern an understanding about connections between science, inquiry, and experimentation, driving her resolve to advance son’s learning:

Olive: Science is being creative; I have always encouraged him to plan projects...even if it means a dirty kitchen, well in the summers mostly. I can move his projects to the garage or even outside but during winters, which is most of the school year or least a good portion, all his projects are on my kitchen floor.

Olive: So it’s like in the kitchen, there are two rooms: my kitchen and Paul’s lab. And I really really have a small kitchen.

Olive views the early opportunities for experimentation emerging as a result of playful activities and uncomplicated cooking endeavors feasible as well as meaningful for young children. During the third meeting, Olive justified use of home-grown projects in the form of compensation for elements lacking at her son’s school:
R: What do you think was the long-term impact of Paul’s ability to “use your kitchen as his lab?”

Olive: I know one thing for sure that it gave him something that was not there at his school. Really, there was nothing at school to help him…because the school did not provide any useful instruction in science…in third grade all they did in science was word match or word puzzles of science related words. Or they saw movies. Good movies but still just movies. That’s not science...take them out to the schoolyard or do simple things with water, or colors or sand. I don’t have a lot of money but I do, I do simple stuff.

In response to further probing, Olive identified comparisons between the informal structure of home-based projects and a laboratory used for conducting planned experimentation, and then, shared personal views about simple projects as important constituents for promoting habits of inquiry in her son:

R: And so you think that Paul benefitted from those experiences. How do you know?

Olive: If nothing else, it taught him not be afraid of messy stuff…You may not like hearing this but we have got to give children some space to be messy. We need to get over the idea of keeping everything at home neat and tidy. If we ask our children to be neat and tidy always, how will they play around with things? Like mixing soap and water or vinegar and flour. I really think parents need to back off a bit. Teachers too.

Since Olive’s reflections purported to include broad recommendations for teachers and parents, I pursued the investigation with her son, Paul in order to gather his comparative insights. After being asked to comment on his mother’s interpretation of her “kitchen [being] used as a lab,” Paul readily agreed that the informal structure gave him ample opportunities to experiment with commonly available household items:

Paul: Me and my brothers used to help out a lot in the kitchen. And I guess it was monthly, me and my brothers…we used to help my mom make, like, one dinner, and it usually was something pretty detailed, but she would always help us out with it. It’d be fish or something like that. So we helped out with that with a lot of details.
R: If somebody could say, “This is [Paul’s] aspect of cooking, and then there’s [Paul] in the science workshop,” how would you tie those two experiences?

Paul: But I see cooking and chemistry pretty closely related, and chemistry is another one of those science-related things. So, I mean, mixing up cake batter, and mixing up chemicals in the lab, I see are very similar. I mean, it is fun too.

In addition to Olive, one more parent indicated similar efforts. Ruthie, mother of an only child, works as a clerical assistant at a retail establishment on most weekdays and sometimes weekends too. Her daughter, Mandy, a senior in a public high school, has expressed interest in pursuing an engineering program. Mandy already has received acceptance from one engineering school, and is waiting to hear from a few more. In addition to her desire for matriculating into an engineering school, Mandy is proud of accomplishments in the school band.

Ruthie had just finished a seven hour shift at the shopping mall when we sat down for the interview:

R: How do you think your parenting has encouraged Mandy’s interest in engineering?

Ruthie: She always showed that interest and I just encouraged it. There were simple things. But she was always doing things.

R: What do you mean by simple things? Can you share some example?

Ruthie: I remember when she was in kindergarten or 1st grade, she saw something on TV, an experiment like thing of filling up a liter bottle of soda and swirl it around and how to make a tornado like force. She was so excited about it she wanted to show the kids at school. So we go with this two liter bottle of water to school and we’re helping her spinning it and all the kids get this big kick of this funnel thing coming down and she got a big thrill out of that.

R: So you helped Mandy conduct her little experiment?

Ruthie: She was always interested in that kind of stuff, experimentation, research type of stuff. I just encouraged it, but she was the one who would came up with
ideas. Then, of course, she was too little to do things by herself, so of course, I would get involved. Then we would [do] things together.

R: How long did this continue?

Ruthie: I remember that when she was in fifth grade, actually the year after fifth grade was done; there was a little project that she took to the neighbor’s house. During summer that is. I remember her saying, “Mom, I can do it by myself. That’s ok, you don’t need to do it with me.”

The above excerpt reveals several different ways through which Ruthie helps Mandy: planning projects; conducting simple experiments at home; participating alongside to complement her child’s developing skills and confidence; and withdrawing gently. In her explanations about the evolving stages within daughter’s growing prowess and confidence in tackling larger and more complex projects, Ruthie outlines several incremental steps through which she provides guidance for her daughter. Because the tasks of procuring a soda bottle, filling it up, carrying it to school, and then demonstrating the experiment in front of classmates were beyond Mandy’s immediate abilities, Ruthie had a more direct and stronger presence. To become a meaningful co-participant alongside her child, Ruthie’s efforts demonstrated two important characteristics: 1) clear understanding of the activity, and 2) respect for her daughter’s evolving abilities.

In the beginning, Ruthie makes attempts to prevent her daughter from ‘failing’ by lessening the constraints; later, as the situation warrants, Ruthie is able to decrease direct support. Through the numerous opportunities to practice under her mother’s support and encouragement, the early childhood experiences likely led to Mandy’s higher levels of confidence in carrying out more complex tasks in later years.
Underlying Common Characteristics

Many of above described efforts by parents are grounded in playfulness and spontaneity; however, there is also a focused attention on inquiry and experimentation within the context of everyday learning opportunities. Several parents are unable to recognize the deliberativeness of their efforts, but not unaware of the outcomes witnessed among their children. Furthermore, a rather small group, totaling no more than one sixth of all parents, identify positive outcomes after initiating informally structured activities leading to discovery and experimentation.

On the one hand, parents like Floyd and Olive provided ample opportunities for their children to practice experimentation and make ongoing revisions. On the other hand, parents like Ruthie involve their children in process by ‘allowing’ them to ask for help. All three parents, Floyd, Olive, and Ruthie, support their children’s discovery and experimentation skills by probing about the activity, responding with constructive feedback, facilitating simple tasks, and providing unconditional encouragement. Some minor differences among these parents can discerned within the individual details; one parent seeks to indulge playful learning, another seeks to provide compensation for school-based learning, while the third reveals gradual retraction of the support provided for her child.

Establishing Foundations of Team Work

Many research organizations view collaborative work experiences as a prerequisite for preparing youth to enter the STEM pipeline (e.g., Commission on Mathematics and Science Education, 2009; National Research Council, 1996, 2004). As
such, extant research claims students’ exposure to real-world problem solving and critical thinking in order to become successful in STEM fields (e.g., Johnson & Johnson, 2009). Such skills are inherently conducive to shared undertakings of multiple people driven by common goals (Commission on Mathematics and Science Education, 2009; Johnson & Johnson, 2009).

Conveying the Significance of Working Together

The reflections shared by two mothers differentiated them from all other participants in this study; both revealed strong beliefs regarding the importance of fostering attributes of teamwork among their children. Debbie, single mother of three teenagers, one of whom attends the ASE program, is a computer programmer for a mid-sized corporation. Scheduling an interview with Debbie was challenging because of extreme time constraints. However, after figuring out a mutually convenient time, the conversation proceeded at a relaxed pace. In contrast to many other parents in this study, she conversed about my research topic with familiar ease. Given her occupation as a computer programmer in a pharmaceutical company, her awareness of STEM fields and underlying factors was not surprising. However, when asked about how she supported her son, Élan, for participation in STEM fields, her responses were fundamentally different from those of several other parents:

Debbie: Right now, I am stressing the pieces that are overlooked by many.

R: Can you explain what you mean by that?

Debbie: We tend to teach children to be the best on their own but how can they do science if they just want to be the best? When I used to work at [name of company], I used to see the scientists huddled together...solving
problems together...one has to understand that, you know, science jobs are too big for one single person. It's not like writing a report or doing some accounting by yourself...this has many pieces...it is massive, it is together. So if your child has not learned how to work together, how can your child be successful in a lab or a research place or even a workshop? You see where I am going with this?

R: So what are you trying to do about this concern?

Debbie: I bring to my child's attention that working together is very, very essential to making it successfully in STEM. The jobs that come out of it are complex, tiring. It requires many people to work together. So, I tell my child on a frequent basis that individuals can fail in tasks that are too big or complex, if they are not successful in working together with others. I also try to show examples to my child so that he can see for himself.

R: Do you think that not knowing how to work together could be a serious deterrent?

Debbie: Yes. We are really are not preparing students for collaborative work like we should be. So they give up their dreams regarding STEM fields. Too soon, I say...too soon because they don't know how to get to the big steps. It is a shame.

Follow-up conversations with Debbie's son, Élan, indicated that her concerns were not unfounded, and her suggestions to rectify those concerns were also not far removed from extant research:

R: Can you tell me what you are doing at ASE nowadays?
Élan: I was working on this big section of the wheel but not anymore. I am really bummed about it. I know everyone was relying on me. I got really excited and really pumped. I put a lot of effort into it. It bothers me when I'm the person on the most important team and then the most important team becomes the not most important team. We were going to do that, but then we decided to go down a different path just because of the way the rules were built and then people (other students) changed their minds.

R: So how did you feel now?

Élan: Because of that I guess I wasn't as pumped for the two weeks afterwards. I know that I didn't really enjoy it as much. I would go there and I would do the work, but I didn't enjoy it as much. I felt that we were going down the wrong path.
R: Will this impact you in any way?

Élan: Hope not but the person...my mentor said that it was not a good way to participate in other ASE activities. Here, you know at the site, there is a big science fair that is coming up; I really want to go there. My mentors felt that I was not being a team player.

While it is not possible to determine whether availing opportunities to participate in advanced activities offered by ASE will have a notable impact on Élan’s long-term prognoses in the STEM pipeline, it is clear that his inability to work together with other students in a cohesive manner is affecting chances for securing additional valuable learning opportunities. His mother’s concerns, while premature about long term prognoses, also appear to be relevant. Later, Debbie revealed further insight into her underlying deliberations:

R: It seems that your concerns about teaching children to cooperate were well founded. It appears that Élan is experiencing some challenges in not being able to work within the large group of ASE students. What do you see happening?

Debbie: Children play with each other all the time at school, at home. They don’t like being alone, so why not expand those habits to teach them other things...I have to make him see that if he really wants to work in research labs as he says he wishes to, he has to learn to get along with other people.

Debbie: I have told Élan that “science is too big by itself.”

R: What do you mean by “science is too big?”

Debbie: What I mean is working in science fields...so I tell him, “you have to learn to work with other children in order to become successful yourself.”

Debbie’s choice of words to describe her concerns is resonant of a deep comprehension about the underlying factors and necessities of nurturing her son’s appreciation for teamwork. It is possible that Debbie’s occupation and educational
background privies her to a more knowledgeable stance about the organizational structures of teams. However, the sentiments shared by Carlina, a Hispanic mother of two and a childcare provider by profession, were not markedly discrepant from Debbie, and neither were the expectations she expressed regarding her son’s learning experiences:

Carlina: I used to work in a research lab well not in the lab...you know I don’t work in a lab but outside, to keep it clean, neat, you know keep it running... I would see that all scientists [leaning] over only one thing...single pieces of paper or samples of lab stuff, you know like football players do. Or I see them going to work on their tables, stations they used to call them...then coming back together. I would see that happening all the time. I say in front of my child all the times: “See how those scientists work together. You be like those scientists. You learn how to work together.”

Both mothers identify concern regarding their children’s inclinations toward individualistic or competitive work, and furthermore, both demonstrate a keen desire for promoting habits of cooperative work among their children. Interestingly, though, these two mothers demonstrate similarities in their reflections and attributions, they represent strikingly disparate backgrounds. While Carlina’s educational background may be revealing of limited access to clear knowledge and understanding, her attributions are aligned with Debbie, whose professional background speaks to direct access and association with such knowledge. And yet, Debbie and Carlina demonstrate only slight variations in respective understandings which may be indicative of social class differences and associated privileges.

Within the positive aspects emerging from the similarities between Debbie and Carlina, however, there is one caveat worthy of attention. True to the affordances of her social class, Debbie is able to explicate concerns, observations, and recommendations with clarity. Although Carlina is able to form impressions of the scientists’ work habits,
she finds herself limited in subsequent capacity to devise analogous suggestions for her child. We see that though Carlina can envision her son to “be like the scientists,” she is unable to offer concrete recommendations for accomplishing the desired goal. It is highly possible that Carlina is limited by lack of access to clear information and deep understanding about teamwork.

Summary

The parents in this study reveal utilization of a broad array of resources in order to sustain their children’s participation in STEM fields. These parents also facilitate the development of wide ranging skills, attributes, and capabilities through which they support their children’s entry into the STEM pipeline (Commission on Mathematics and Science Education, 2009). The skills and dispositions range from mathematical and computational skills to awareness about problem-solving and experimentation, and include appreciation for teamwork among children. These parents’ critical attentions towards development of spatial skills and their understanding of relationship between mathematical oriented activities and experiential learning, offer a good example for discussing this study’s findings. Three fourths of total parents recall concerted efforts of comparable nature.

Another characteristic of importance is the consistency with which many parents, fathers and mothers, provide support of comparable nature for their boys’ and girls’ educational progress. The participants’ narratives informing this study are also indicative of a few thought-provoking exceptionalities. For example, contrary to extant research, the accounts of three fathers reveal respective interactions with their daughters within the
context of mathematically oriented activities. Furthermore, two of these fathers claim that sustained efforts towards providing appropriate resources, opportunities, and learning experiences are instrumental in fostering their daughters’ confidence and success within science and mathematics. The evenness with which fathers and mothers extend similarly targeted support to their boys and girls belies extant stereotypical conceptions about the differential treatment of boys and girls by fathers and mothers.
CHAPTER FIVE: SIDESTEPPING THE ACCEPTED NORMS AND THE ACKNOWLEDGED EXPERTS

Introduction

For an extended period in the United States, the responsibility of educating children and adolescents was viewed within the sole purview of schools and teachers (Westmoreland, 2009). During the 1950s, a dominant discourse emphasizing the importance of parental involvement in children's education began to emerge, and as a result, many parents began to view the education of children worthy of their attention and also as a prerogative (Epstein, 2001). Later, some researchers made claims that the delivery of meaningful education be viewed as a distributed responsibility shared among formal institutions like schools and informal establishments such as homes and communities (e.g., Epstein, 2001; Epstein & Sanders, 2000; Westmoreland, 2009). Still others claimed that schools and families provide complementary learning opportunities for K-12 students (e.g., Bouffard & Weiss, 2008; Westmoreland, 2009). Throughout the changing dynamics, schools have been viewed as primary venues of learning, and similarly, teachers as essential providers of guidance and educational resources (Bouffard & Weiss, 2008; Garcia Coll & Patcher, 2002; Lareau, 2000, 2003; Westmoreland, 2009).

Investigation of the data sources informing this dissertation reveals that parents make deliberate efforts to expand their children's learning by seeking external resources, many of which are situated outside the conventional domains of responsibility and expertise. My research demonstrates that instead of relying on schools to provide children's educational needs, and taking existing structures and norms for granted, a large
majority of these parents make extensive and strenuous efforts to establish learning opportunities for their boys and girls outside the traditionally defined confines of schools. In this study, the notion of “breaking old habits” was seen among a mix of middle class as well as working class parents. This research reveals numerous examples of facilitation of children’s education through the use of unconventional means, both among fathers and mothers, though more frequently among the latter.

I found that approximately three fifth of parents incorporated alternative ways of learning through OST opportunities, established beneficial relationships with people whose professional expertise is clearly located outside of schools, and used a variety of information sources in order to support and steer their children towards sustained participation in STEM fields. The majority of boys and girls in this study also identify positive impact as a result of parents’ unorthodox methods and willingness to sidestep conventional means of resources, guidance, and ideas.

What are OST Learning Opportunities?

Some researchers posit that out-of-school time (OST) educational programs provide meaningful learning opportunities in STEM fields (e.g., Deschenes et al., 2010; Hill, Corbett, & Rose, 2009). Some others claim that OST learning opportunities may hold the potential for providing youth with the skills necessary for success in the 21st century (e.g., Basu & Barton, 2007; Heckman, 2008). Bouillion & Gomez (2001) posit that learning environments that exist beyond classrooms provide “connected meaning(s) for learners” by utilizing “powerful bridging of contextual scaffolds” (p. 879). In response to recommendations of extant research, regional, state, and national level
organizations have made substantial investments in OST programs in order to support broader participation in STEM fields (Commission on Mathematics and Science Education 2009; Deschenes et al., 2010). More recently, research has established that OST is important “for middle and high school youth, whose participation in OST programs can help keep them connected to positive role models and engaged in their education” (Deschenes et al., 2010, x; see also Bouillion & Gomez, 2001; Hill, Corbett, & Rose, 2009; Lowery & Brickhouse, 1993).

For students who lack access to meaningful and engaging learning on routine bases, OST programs have the potential to facilitate their informal enculturation into stimulating environments for learning science and technology (Bouillion & Gomez, 2001). In spite of several research studies indicating positive outcomes as a result of participation in OST programs, the scale of retention in OST programs for youth has not been particularly impressive (Commission on Mathematics and Science Education 2009; Deschenes et al., 2010; Eccles, 2006). According to Deschenes et al. (2010), only 18 percent of middle school and 12 percent of high school students participate in OST programs.

The field of STEM education lacks a vast body of literature which is able to identify specific benefits of OST learning. As a result, it is more difficult to ascertain the characteristics of OST programs that may ensure success in STEM fields (Basu & Barton, 2007). Therefore, for the purpose of identifying broad understandings regarding the essential features of effective OST programs, this study uses the findings from “Issues and Opportunities in Out-of-School Time” published by the Harvard Family Research Project (Westmoreland, 2009). According to the above report, important features of OST
programs include leadership opportunities for participating youth; trained staff; community-based; enrollments of 100 or more youth; and more than four years of existence (Westmoreland, 2009).

Among those who believe that STEM education can be provided through OST programs, a few also posit that “youth from lower-income families and neighborhoods have fewer OST opportunities than their more privileged peers” (Deschenes et al., 2010, p. 1; see also, Ladson-Billings, 2006). The opportunity to participate in meaningful STEM experiences is particularly limited for children from disadvantaged backgrounds such as urban areas with under-resourced school districts. Often, the challenges faced by many students get compounded because they attend schools which are unlikely to provide high quality STEM education and lack of high quality OST learning opportunities in their local communities (Bouillion & Gomez, 2001; see also, Ladson-Billings, 2006).

Parents’ Perceptions about Advantages of OST Learning Opportunities

The parents and students included in this study are characterized by a common identifier: their relationship with the ASE program. The study participants share another commonality: almost, unanimously, parents and students identify positive impact of the ASE program coupled with simultaneous explanations regarding absence of comparable opportunities at their children’s schools.32 Parents’ responses on the preliminary survey also reveal their high approval ratings for the learning opportunities provided by the ASE program. On a scale of 1 to 5, where 5 denotes the highest rating, out of 34 parents, 19 parents accorded the ASE program a “5,” 8 gave it rating of “4,” and no one gave a rating

32 One student disagreed that ASE provided him with any added value
of “1” or “2.” Additionally, in response to the open-ended questions included in the parent survey which sought parents’ perceptions about additional advantages that might have benefitted their children, 11 parents indicated that access to other OST opportunities prior to joining ASE would have quite likely made a meaningful difference for their children, and 12 indicated that financial concerns had prevented them from enrolling their children in fee-based OST programs available through universities, museums etc.

Keri and her husband live in a middle class neighborhood. Their two sons and a daughter attend local public schools. Recently, the oldest son applied to a charter school that accepts students on selective academic bases. On the day this interview was held, Keri and her family were anxiously waiting for the school’s decision. Keri shared that she did not pursue formal education after finishing high school and now works as a daycare provider at a local community center crèche. Her husband has an associate degree in biology and works at a local pharmaceutical company.

2009-2010 was her son’s first year at the ASE program. Further, Keri acknowledged that so far, association with the ASE program has been a positive influence on her son’s learning and motivation. The following excerpt is taken from an interview with Keri conducted at a coffee shop located near the ASE site:

Keri: And that’s what I love about, especially these programs, ASE and the other robotics group which is associated with this, because it helps these kids figure out what they like and what they don’t like. And if he doesn’t like programming, at least he learns something along the way. In [down] time, you know, he’s here talking to other kids about interesting stuff. Just stuff like building and constructing. He is figuring out with them what can be done. He’s got great mentors who are doing this for free, and he’s really learning something that if he doesn’t want it he can always stop. There are no bindings, like none. None. No grades. Just doing interesting things.
As can be discerned from the above excerpt, Keri voiced uncontained excitement and pride related to her son’s participation in the ASE program.

R: Is there anything else you want to tell about Andy regarding his participation in ASE? What do you like about ASE?

Keri: It seems to be a very well put together group of kids and mentors. This is our first year so everything is like wow wow to us and so exciting. We are so much in wow of the program. Our son is getting to do such cool stuff. In some respects I wish we could do more, could have done more earlier, but it is a balancing act with three children and two jobs that don’t have [flexible] hours. R: So it does appear that you have to make a lot of sacrifices in order for your son to attend the ASE program, What kinds of benefits do you see that tell you that all the efforts you put in are worth the trouble?

Keri: It’s like, he tell us, “I could never do that in classroom in the physics lab class, but now that we are working on this together, [Sally] and [Bob], or [Jim] and [Bob], and together we’re doing it.”

Notice how Keri articulates the advantages for her son through his engagement with the ASE program through the repetitious use of “wow.” She sees her son benefitting from the interconnected effects of new knowledge and real-life experiences coupled with the positive social experiences available through the ASE program. Keri claimed that participation in the ASE program was important for her son because by eliminating the stifling aspects of routine activities and their “bindings,” it made up for the gaps in his current school’s learning environment.

Later on, when I interviewed Keri’s son, Andy, he agreed with his mother’s viewpoints:

Andy: Well, at here [ASE], I learn a lot here. I really have fun here. It’s one of the things that is really important to me in my life.

R: Why is it important to you?
Andy: I enjoy it and I learn a lot. I just feel that it is important to learn these things. Today I actually helped build my shed for the new tool. I had help from someone who is more knowledgeable in woodworking but there are definitely some main skills that you can learn about building anything. This really excited me and just knowing the tools is also really helpful. I feel that I learn a lot here and I have fun. It’s just, I just feel that it is very important to me.

R: Who encouraged you to join [ASE]?

Andy: Mostly my father. My mother had heard about it too from some of the parents who drop their babies at the center. I guess. They both thought that it would give me a chance to learn what physics is like really about, like what it does.

Andy: Oh I remember now, there was this lady, she knew the mentor. So she’d be telling my mom about it; and my mom would tell me or show me, and...I just knew like when I had a chance, I would join [ASE].

In the above, Andy conveys that before joining the ASE program, he did not have access to opportunities that allowed him to bridge classroom learning to real-world situations. Andy’s comments demonstrate the positive value he perceives in learning through real-world problem solving under the guidance of experienced professionals. Additionally, Andy notes the ASE program provides him an opportunity to test out the meaning and application of physics within social experiences with peers of similar age. Finally, Andy is aware that a family acquaintance informed his mother about the ASE program. All these aspects are notable because they point to Keri’s unconventional approaches and her willingness to step outside of traditional norms.

Extended Benefits of Working with OST Mentors

Other kinds of benefits resulting from their children’s participation in the ASE program were identified by still more parents. Among them was Janey who lives in a
quieter and more affluent part of the city. She is an electrical engineer whose professional background could be easily discerned from her fluent usage of technical terms. Janey is divorced and has two children, an older son and a younger daughter. Since she works at a mid-sized electronics company, just like Debbie in chapter four, Janey’s access to external sources of information and connections with people who could possibly guide her son to interesting opportunities for learning about science and technology would be considered reasonable. During the course of the interview, some of Janey’s comments indicated a deep understanding of STEM fields; however, they also demonstrated a deep sense of relief in being able to enroll her son, Kevin, in the ASE program.

Janey: I don’t have many activities where my kid would want to come back running for a year or so because the person in charge doesn’t know how to handle students. I think [ASE] does that well. That they have, and I don’t know if this comes from the professional side from their ability to facilitate to the students, handle the students, the general crowd control of 30, 40 high schoolers who all have ideas. They do extremely well on that. I now have a very strong opinion that anyone who teaches and has no ability to control high schoolers. There is no value.

R: So this kind of programming is good for [Kevin]? 

Janey: Absolutely. There is a structure of good, hard work ethic. There is a notion of concept to end. Also the process to produce cycle. But also loose ended…it’s like anything is possible. It’s something that you don’t necessarily get until you are in college and sometimes not even in college. Here [Kevin] is getting it at school level but not at school!

From the above narrative, it can be concluded that Janey believes her son is engaging in open-ended investigations and problem-solving through his participation in the ASE program. Janey’s descriptions of her son’s positive experiences are closely aligned Bouillion and Gomez’s (2001) recommendations, who advocate for a focused
attention on providing “real-world problems that have no clear answer, are interdisciplinary in nature, are relevant to both curriculum and students’ lives, and are highly visible and accessible” (p. 895). In spite of reasonable assumptions that can be made about Janey’s access to meaningful resources for her son, she is seen welcoming the benefits of participating in the ASE program.

Parents’ View about the Compensatory Advantages of OST Programs

Similar to the manner in which Keri and her son appreciated the learning advantages of the ASE program, Janey also recognizes the benefits of an OST program which provides learning in STEM fields. Additionally, Janey recognizes that success in science and technology requires adolescents to be immersed in a learning environment identified by a unique set of norms, values, work ethics, and skills. Janey attributes her son’s success and satisfaction to affordances of questioning processes, conducting investigations, and constructing prototypes based on self-generated data. Yet another way of recognizing Janey’s satisfaction about the ASE program is through positive feelings regarding her son’s participation alongside a large number of similar age youth from diverse backgrounds. In Janey’s view, shared responsibilities for solving problems and carrying out projects keeps her son excited and engaged in learning about engineering and information technology.

However, in contrast to Keri, Janey’s account also offers a glimpse of disdain for some practices that are prevalent at Kevin’s school:

Janey: There are programs at the school too...but...also, there is a lot of unnecessary competition which really frustrates the children. At least my child, he
is actually very good in being creative, but he does not like struggling or competing for each little point.

R: Can you give some example of what you mean by that?

Janey: So at his school the way science Olympiad works is that all the top half kids have to compete, then the top 15 kids are chosen for the training. Well he did not make it...he was 17 or 18 in the lineup. Maybe 19 but that's it. Now he was out...I said let him just come to the training class he doesn’t have to compete just be part of it. The teacher said no because that would add to her burden whereas she wanted to concentrate on kids who had a chance of winning...so he, he got left out. In some ways, being at a weaker high school would have been better because he would have had more opportunities.

R: Have you had these conversations with his teachers, expressed these concerns to his teachers?

Janey: Not very much these days. When he was younger we were sort of there more, but now since he has been in high school, especially, I get a meeting with his advisor once or twice a year. Schools have a tendency to screen and cherry pick for each opportunity. [ASE] makes it equitably accessible, letting everyone compete, participate. I like that. I think [Kevin] likes it too. I think he really likes being there, here. This is the most satisfied I have seen him in a long time.

Janey believes that compared to the intense competition witnessed at school, the ASE program provides her son with “a non-threatening and non-academic environment for hands-on learning that is collaborative, informal, and personal” (Chun & Harris, 2011, p. 1). Furthermore, she appreciates that intense competition is nonexistent at ASE; instead the program is based on building equitable discourse and shared tasks among youth. However, Janey is also seen ascribing to a belief of “Big Fish-Little Pond” by indicating disapproval for the academic competition at a highly competitive charter school, as a result of which, she is convinced that her son’s access to learning opportunities have been limited.
Further conversations with Janey indicate her recognition of positives outcomes realized from working in collaborative settings. Again, this last aspect is also something which she identifies as another key component that is missing in her son’s school:

Janey: They are taught to work with groups. Not just within their team, they are taught to work with other teams and they don’t know who they are going to get. But they are taught, you are maybe going to get some teams that don’t have a very good robot but it is the luck of the draw and we have to deal with it and work with them and maybe try and help them get better. Instead of it being about me, me, me, me, they are taught to help people around them.

A closer investigation reveals that the benefits identified by Janey as a result of her son’s participation in the ASE program are mirroring the concerns shared by Debbie and Carlina in chapter four. Although the perceptions shared by Janey, Debbie, and Carlina are focused on similar concerns, there some distinct differences among them. Janey recognizes that by participating in the ASE program, her son Kevin understands the intimate aspects of teamwork and cooperation. Debbie and Carlina also recognize their children are in critical need of gaining familiarity with finer details of teamwork. All three women’s children participate in the same program; however, only one makes clear references to the ASE program’s contributions in providing her child with an understanding of teamwork, while the other two are still searching for solutions to meet their children’s specific needs. Interestingly, as of yet, Debbie and Carlina have not been able to locate the benefits of these attributes within the ASE program. While, they are aware of the need but are not recognizing that ASE is possibly addressing their concerns.
Parents’ Perceptions about the Complementary Values in the Roles of Schools and OST

Some researchers propose the beneficial outcomes of positive relationships between schools and families based on mutual trust (e.g., Harvard Family Research Project, 2008). However, other researchers (e.g., Reali & Tancredi, 2004) claim that in spite of widely recognized benefits of strengthened relationships between home and school, “parents and teachers often lack the dialogue that supports positive relations between home and school” (p. 1).

In this study, three parents including one father and two mothers revealed efforts to simultaneously seek help from both school and OST organizations to provide for support their children’s entry into STEM fields. In the following, Lori, mother of a 16-year old boy, identifies advantages harnessed through a dual engagement of school-based teachers and OST mentors:

R: Do you have conversation about your child’s explorations of science or technology or whatever his interests with parents of his friends, or the teachers?

Lori: Well some of his teachers. He has a really great physics teacher this year. And we were talking about the ASE program and I was talking to him about my son and how he used to build in the sand all of the time and he would build these tunnels and bridges and that he could stand on and I would always say to him, “if you stand on that bridge it’s going to fall through.” And he would say, “No mom, I built it where it’s not going to fall through.” So I knew he understood that, how to create things withstand pressure. So I was talking to his physics teacher about that, so he suggested what kinds of activities might be good for him.

In the above exchange, notice the unhurried aspects of a prolonged interaction taking place between the parent and the teacher. In the above, Lori attributes the teacher’s guidance for encouraging her son’s enrollment in the ASE program. Lori’s son,
Chris, also reveals appreciation for his mother’s efforts of simultaneously reaching out to both teachers and OST mentors in order to seek information that she can then utilize for facilitating his progress:

R: Do you talk about these ideas of what you want to do with your parents, to your teachers, or counselors?

Chris: Yeah, I talk to my parents, and I have talked to my physics teachers, Mr. [name] about it. He is just known as Mr. [name]. I don’t remember his first name.

R: That’s alright. Who initially encouraged you to join [ASE]?

Chris: I think it was my mom and see, my mom is friends with [mentor’s name] so I from there I guess she thought it would be good.

Chris: I didn’t really know much about [ASE] before that. So my mom did more search and I knew kind of what it was. And she talked to Mr. [name]. He also thought it was really cool and interesting so I thought I would try it out. I applied, I did that.

R: That’s great. So do you talk to other people, such as counselors?

Chris: We do have counselors, but mainly they are for college searches which is going to start next year. Then I will go to them. Now I talk to the mentors. I talk to my friends here (at ASE) about it too. Like which colleges are good...where can I get in...like that kind of stuff.

R: What about your parents? Do they talk to teachers and counselors?

Chris: They do, but I think they feel more comfortable talking to Ms. [mentor]. Maybe I see them here so that may be it. I don’t see them (parents) talking to my teachers or counselors. That’s closed. Like close[d] doors. So don’t really know.

Although Chris identifies a close rapport with his physics teacher, he appears to harbor a misconception that counselors can only be useful for providing information about college admissions. It is possible that Chris’ unawareness can be attributed to the fact that meetings between parents and counselors at his school tend to exclude students
and are often held behind “closed doors.” This may also account for why Chris believes that his parents “feel more comfortable” in interacting with an OST mentor because the discussions take place in open view. Chris’ comments represent the perceptions of a few more parent/child duos in this study in terms of the complementary benefits of schools and OST programs. For example, the following exchange demonstrates a mother receiving meaningful information tailored to child’s specific needs from a school teacher, and then, using the teacher’s advice to enroll her daughter in a summer program:

R: Do you they ever tell you “These are [Becca’s] strengths and we should build upon them. Or this is what we think she needs help in”

Mary Ellen: Yes. She has told us. One of her teachers suggested that and she’s also known other older kids that have gone to different programs. Actually last summer, we sent her to a camp for ten days that was called [name]. It was available free through the [state university].

R: Now what did [Becca] think about it?

Mary Ellen: Our daughter? Well, [Becca] didn’t know anyone personally that done that medicine one, but she went and loved it.

R: How much do you interact with school teachers or counselors about her progress, her well-being, and about her future tracks?

Mary Ellen: Yeah. We have talked about things like that, yeah.

The above accounts recognize the advantages realized by parents and their children through parallel engagement of schools and OST learning opportunities whether after-school, on weekends, or during the summer. For some parents like Lori and Mary Ellen seeking the help of teachers and counselors at school appears to be a feasible process; however, this study was not able to identify many other instances that speak to parents’ engagement with school personnel for seeking information about OST learning
opportunities for their children. Instead more parents were found seeking the advice of external sources than school-based personnel.\textsuperscript{33}

\textit{Ambiguous Perceptions among Parents}

During the course of the study, it became apparent that many parents used OST learning opportunities to enhance their children’s in-school learning, especially to provide experiences related to the application of biological sciences and engineering within everyday situations and occupations. However, some noticeable ambiguities regarding the added value of OST learning opportunities were discerned in at least one parent, Ruthie, mother of 16 year old female. On one hand, Ruthie claimed seeing positive changes in her daughter as a result of participation in OST opportunities; on the other, she declared that the real reason behind encouraging OST participation was influenced by “that’s what colleges are looking for.” Compared to the majority in this study, Ruthie’s supposition was of an entirely different nature but I was not able to obtain any further clarification from her.

\textit{Does OST Preempt Learning at School?}

In spite of overwhelming emphasis on OST learning opportunities witnessed among large numbers of parents, a related attribute that became apparent during the research was that approximately one third of parents indicate firm grasp on different priorities. Regardless of how “not engaging” or “boring” schools appear to their children, several parents claimed giving higher priority to school work. Furthermore, the

\textsuperscript{33} More details provided later in this chapter
study revealed that at least some students are well aware of their parents’ positioning and preferences. For example, Kendra expressed confidence in knowing that if her parents had to choose between school and OST; there could be no doubt about the positioning of their priorities:

R: When you are talking to your parents, it's supposedly quite natural that sometimes your opinions don't coincide with your parents'. They might be thinking differently about activities beyond school. Do you have those kind of moments where your parents think "this activity is more important than this one?"

Kendra: Well, my parents definitely think that school is top priority. If it's a question "you have a lot of homework, do you go to [ASE] and not do your homework. Or do your homework. It's always stay home and do your homework."

R: How do your parents help you prioritize? Do they talk about priorities? Do they indicate what they feel about each situation in its own right?

Kendra: Yeah definitely. School has priority. I love coming to [ASE]. I don't think I've missed a meeting yet. I like coming to it. But, but they also tell me to, to leave early to study for some boring test.

R: And do you go then?

Kendra: Well yeah, well actually, I went [home] this past weekend. I had a test today, I needed to study. Both my parents hugely stress that schoolwork is important.

R: What about your responsibilities at ASE? Did you discuss those with your parents?

Kendra: Well yeah. But they think that doing well in school is more important.

R: Why?

Kendra: They say something like: “If you don’t do well in school, how will you get to college?” I don’t like it but I do think they are right.
Kendra’s parents were joined by at least four others who acknowledged similarly inclined thoughts. The collective significance of their accounts leads to an interesting nexus. A large majority of parents express strong opinions about the positive value of OST programs for their children’s learning; the students’ reflections provide further confirmation of the parents’ confidence in OST programs. Although many of these parents recognize the beneficial aspects provided by OST programs within the context of their children’s progress in the STEM pipeline, they are not unaware of the importance of schools or course work. In spite of the overwhelmingly positive attributions among parents and students, at least some of these parents are neither willing nor ready to relinquish their prioritization of school-based learning over OST learning.

Making it Happen for their Children and their Children’s Friends Too

The efforts of a small group of parents in this study are demonstrative of more unusual ways to address specific gaps in their children’s learning environment. After identifying the factors holding their children back, these parents implement rather uncommon strategies.

Maxine (who has been referred to in an earlier chapter also) and Kendra are sophomores in the same school. Although slightly acquainted with each other before joining the ASE Program, these two girls did not “hang out with each other” until recently. For many months prior to joining ASE, both girls had independently expressed interest in attending a science intensive summer camp. According to their parents, both, Maxine and Kendra were hesitant to attend the camp, albeit for different reasons. Kendra has been desirous of attending a science camp for a longer time than Maxine. However,
more recently, Maxine has been more resolute than Kendra who had lately started wavering from her longstanding aspirations. While Maxine was reluctant to enter an unfamiliar environment on her own, Kendra feared that “three weeks of science would be too much science.”

Recently, circumstances began to look promising for both girls; both have enrolled in a three-week summer camp offered by a university located four hours away from the girls’ hometowns. Investigation of how Maxine’s and Kendra’s parents enabled both girls to negotiate their aspirations and hesitancies reveal intriguing aspects of their efforts. Individual interviews with both girls and their mothers shed further light on the underlying details. Maxine’s mother, Abigail, was delighted that her daughter’s longstanding wish for attending a much sought after summer camp focused on forensic sciences had been achieved:

Abigail: And I think it was a lot of recruiting through her friend [Kendra]. I think that she would have had trouble doing it herself, but as long as she had a buddy, so to speak, and somebody pushing her. But she definitely needed a friend to make that plunge. Am so glad [Harold] (husband) and I talked to [Moira] (Kendra’s mother) to find a common session and that we can carpool together. [Harold] and I attended an open house earlier in the year, and brought two sets of information packets. One for them ([Kendra’s] family) and one for us.

R: In your opinion, what makes this camp exciting for [Maxine]?

Abigail: She likes to learning with, to use her hands, thinking, troubleshooting, problem solving and tools. She is good at problem solving. But you know she just was not able to pull the courage to go alone.

R: So are you saying that now it doesn’t seem to intimidate her that she’s participating in a forensic camp four hours at a large university?

Abigail: It doesn’t seem to now. But used to! Now? Well, no! It is OK. She felt good because everybody around her will be a nerd. She has always wanted that. And now with with a friend, she will go. And it is good for her. And I think that
she really likes it.

According to her mother, Maxine exudes a level of confidence that was lacking before she met Kendra. The change in Maxine became possible through the support of a peer who also had some doubts, though, of a different kind. During the interviews with Abigail and Moira, I was not able to identify strong emphases on acquisition of any specific skill sets by either mother; their accounts were resonant of appreciation for the positive influence exerted by children’s peers.

This study revealed two more situations of similar magnitude and impact within the parents’ efforts. Consider the case of Amy, a sophomore, who attends a charter school located near the city border. She claims to be an avid rock collector and makes regular visits to the county library to read the “Rocks and Minerals” journal. Frequently during the interviews with Amy’s father and stepmother, I heard several references to uncommon practices initiated by them in order to sustain their daughter’s interest in rocks and minerals. For instance, just a few months ago before the interview, they invited Amy’s friend from church to accompany them on a visit to Crystal Caves in Kutztown, Pennsylvania, to see deposits of calcium. Amy’s stepmother shared reassuring views about the process and its outcomes:

R: Amy told me about your trip to the Crystal Caves along with her friend.

Teri: It was very interesting. We finally made it. Amy’s wanted to go there for a long time.

R: So what changed this time around?

Teri: She wanted to go but not with us. I thought…think it was like “what self-respecting teenager wants to travel with her aging parents?” You know that sort of thing. So we invited her to bring a friend, we paid for the friend’s ticket and
meals. Not always easy. But you know what, it was way worth it. Amy has been so excited ever since, she is reading more books on rocks, the other day; she sat glued to the Discovery Channel. She traced the history of the caves and how they were discovered.

Teri: With our other children, we have paid for movie tickets and eating out. But nothing like taking two teenage girls, mind you two geeky teenage girls to see a rock collection. However, so so if taking a friend to such outings inspires her, we are willing to take the trouble. We will have to talk about the expenses though.

R: What do you think the impact was on Amy’s friend?

Teri: Looks like, she was ‘turned on’ by the experiences because I heard them both (Amy and the friend) making plans to watch something on the Discovery Channel. I know that this friend would have rather watched some sitcom but at least she was excited enough by the experience to watch Discovery Channel. For Amy, it is good to have someone other than her parents with her.

In both situations described above, the parents appear to have exceptional insight about their daughters’ respective sources of hesitation. In both situations, parents are actively seen reaping the benefits of supportive friendships for their daughters. Their actions demonstrate engagement of children’s friends in order to sustain their daughters’ enthusiasm for learning about STEM fields. Considering that relatively speaking, girls tend to experience higher rates of attrition from pursuing educational opportunities within STEM fields, the early actions taken by these parents may have significant long term positive outcomes.

As been frequently seen before, after comparing the two sets of excerpts, a distinct difference can also be surmised. In the case of Kendra and Maxine, the parents’ facilitations manifest within a more structured endeavor to send their daughters to a three-week summer program which likely required substantial investments of money and efforts. In comparison, Amy’s father and stepmother initiated an informal excursion for
their daughter and her friend. Yet, regardless of the different ways through which these parents support their children's interest in STEM fields, they reveal a group of satisfied parents, and students who have realized their goals at least for the short term.

Seeking External Sources of Information

It is widely acknowledged that historically, parents have depended on information and guidance available through various school-based sources for advancing their children's education and general well-being (Epstein & Sheldon, 2002). In contrast to extant understandings, in this study, it was found that instead of using school teachers and counselors as their primary sources of information, many parents seek the advice and support of extended family members, friends, colleagues, and employers. Parents' accounts revealed their dependence on two distinct categories of sources for obtaining information: social networks and mass media.

*Using Social and Professional Networks*

For the purpose of this study, parents' social networks can be viewed as formal or informal (Steinberg, 1989). Formal networks are witnessed in the form of memberships in organizations governed by laws or guidelines, whereas, informal networks lack clear organization, and instead, are generated in response to emergent needs. Accordingly, Parent Teacher Associations (PTA) can be understood as examples of formal networks and relationships with friends or co-workers as instances of informal networks. Recent studies have revealed that in comparison to parents from working class families, parents from middle class backgrounds are more likely to use social networks consisting of
extended family members, friends, and other parents at the same school in order to articulate their children’s needs and seek relevant resources (e.g., Cucchaira & Horvat, 2009; Ream & Palardy, 2008). However, this notion is disputed by others who claim that parents from working class backgrounds also establish own set of social networks for seeking advantages and information benefitting their children (e.g., Kerbo, 2005; Lareau, 2003; Pattillo, 2008). These researchers claim that the key difference between the two groups is not the willingness to seek outside help, rather, in the level of knowledge and access to sources available to people with whom parents establish connections (e.g., Kerbo, 2005; Lareau, 2003; Pattillo, 2008).

In the above context, it is useful to consider the case of Laketch, a mother of five children, two boys and three girls, all of whom attend public schools. She immigrated to the United States from an east African country about 25 years ago when she was in her early twenties. Thereafter, she attended part-time evening school to get an associate degree in business, and simultaneously learned English. Now she works as dispatch secretary for a trucking company. Her oldest daughter, Daria, has attended the ASE program for the last two years. Laketch and her husband live approximately 17 miles away from the ASE site. Only one ASE student lives farther away from the ASE site than Daria. It is easy to conclude that Laketch has to make significant allocations of time and efforts to transport her daughter to the ASE site.

Laketch shared a deep regret in not being able to guide her oldest child, a son, in a satisfactory manner, and as a result, became more determined to make concerted efforts towards supporting Daria’s education:
R: Can you share some information as to how Daria got involved with [ASE] program?

Laketch: Well, my middle daughter was in Lego League in her old school and once we went to Lego League events, and it was being held at [name] school and at the time Daria was involved in a science program through the school. But that led to nowhere. It just fizzled and nothing happened. We went to the PTA lady, woman to ask. Nothing again.

Laketch: So my husband and I thought, well like how people here say “the old ain’t working no more.” But our kid was interested in doing science stuff. I’m not sure if you can understand. You know, like she is very interested.

R: So what happened that led you to [ASE]?

Laketch: So I was telling my boss about it all. And then my boss started mentioning ASE and the kids and the mentors and all of that stuff and I realized that that would be something that would interest Daria. And so I asked her if she was interested and when she said yes, I phoned [mentor]. I told him that my boss mentioned it.

R: What else have you discussed with your boss? Has he advised you on anything else that you have found useful?

Laketch: Oh yes! See...he was the one who told me that if Daria really wanted to attend engineering, she had to be good at math. He told me to tell her to work hard in math and not just give up. He also told me to make her practice, practice math so that she gets higher scores in the SAT...Well we did...So you know that she has applied to three engineerings [schools]. I think I already told you that.

R: So I am gathering that you trust your boss to give you helpful suggestions. Have you had similar conversations with the teachers or counselors at Daria’s school?

Laketch: Well, once we met with the guidance counselor. They have the parents’ night, you know. We went around and sat for 10 minutes in each class. You don’t get to learn a whole lot that way...Teachers don’t really know much beyond their own areas...the guidance counselor we talked to did not know what colleges are good for computer majoring...majors. No no, actually computer engineering, that’s what Daria wants to do. But they were nice to us. Real nice.
Several different themes of emphases emerge from within the above narratives. First, Laketch identifies proactive efforts in sustaining her daughter’s interests in science and engineering by seeking advice from a boss with whom she has a positive and comfortable relationship. Second, by pointing attention to the importance of mathematics, the boss is introducing Laketch to knowledge that was not within her prior considerations. Laketch is not entirely dismissive of school personnel or of their expertise; however, she acknowledges more respect for the external advice in terms of the impact on her daughter’s education. Finally, though, Laketch is basing some perceptions on approximately ten minutes spent in each classroom, she is able to recognize that meeting teachers whose expertise is not geared to her child’s individual needs is unlikely to yield constructive outcomes.

*Use of Mass Media to Identify Learning Opportunities*

Mass media was the other important source identified by parents for obtaining information about venues, resources, and possibilities of OST learning. For the purpose of this study, mass media includes the Internet, print materials like books, newspapers, and magazines, radio, and television. It is understood that the messages conveyed through mass media are disseminated in public domain and are not addressed to any specific person or group. Further, information delivered through mass media reaches large sections of the population in relatively short periods of time, i.e., the time spread between the dissemination of information and its retrieval by consumers is relatively short. However, some researchers have found that though parents and young people have many options to obtain information about careers and career paths, they are not able to
sift through all the publicly available information in objective ways (e.g., Cleaves, 2005; Jacobs & Simpkins, 2005). In addition, some researchers posit that educational and career “portrayals are often quite gender and ethnically stereotyped” (Jacobs & Simpkins, 2005, p. 10).

A large number of parents as well as students in this study affirmed parents’ use of mass media for expanding children’s educational opportunities, and more interestingly, for verifying information received from schools and teachers. The most prevalently utilized means were Internet-based sources, followed by print media. Only three parents (less than one tenth of the entire research sample) claimed finding useful and transferable ideas from television programs. Internet-based sources were found to be popular with parents of boys and girls, demonstrating fairly even distribution among them. These parents were found using various means of mass media to search for colleges and other post-secondary institutions (n = 5); to search for summer camps (n =11); to search for information regarding fee-based summer programs (n = 3); to search for tuition free summer programs (n = 5); to search for informal, small scale, or family-based activities in STEM fields (n= 12). Many parents acknowledged trust in information available on websites hosted by universities, schools, and research organizations. A few parents claimed finding blogs hosted on the websites of prominent news organizations useful sources of information that could be applied in the context of their children’s educational requirements.

Cheri, a single mother of seventeen year old son is among those parents who use the Internet as a primary source for researching information pertaining to children’s education. Her son, Anshua, is a junior in a publicly chartered school and has aspirations
of attending an engineering school through dual enrollment in the ROTC program. While Cheri is not struggling for day-to-day expenses, it is not feasible to send Anshua to summer enrichment programs or pay for college without the help of financial aid. She revealed ongoing attempts to enrich her son’s education by using free resources available through public libraries or museums. Cheri discussed making video recordings of shows aired on the Discovery Channel or Public Broadcasting Networks to advance her son’s knowledge. I pursued further investigation by individually interviewing Anshua:

R: All that you have told me so far is helpful. She pays for some magazines, she drives you, you have apparently good conversations with her. However, if there was one thing that you could identify in the way your mother supports you, what would that be, that’s so critical that you think that “oh this my mother does for me and it’s just awesome?”

Anshua: Yeah. I know what you mean. I would definitely say her ability to search up all kinds of information.

R: Does she look for information that she finds useful for you? Do you tell her to look up stuff or does she know what you might need?

Anshua: It’s like everything. Like I’ll say, it would be great if I, if I could go to college on ROTC. She’s found some college programs online. Actually, she’s found a couple. She has looked into summer internships for me as well as more information about ROTC and colleges and stuff.

R: Have you pursued any of those summer internships?

Anshua: No. Not as yet. She found one with the Navy Research Laboratories, but next year I should be able to, but I just missed the deadline when she found it. She told me to mark on the fridge so we can both remind ourselves to apply next year.

In the follow-up interview with Anshua’s mother, a ready agreement with her son’s reactions was quite evident. Her comments revealed a wide range of activities and information that she finds on the Internet or through television programs:
Cheri: Well, we’ve done a lot of trips to places that, we like to do historical things, but we’ve done trips to a lot of museums that are science related. He’s just always fascinated by how things work. We watch a lot of the Science Channel, all the different shows that they have on designing things and how things work. Things like that. He has done some extracurricular things. Different stuff, but some of the things he did go for were how design things, how to build. I get on the Internet and look for free stuff. One time I paid $35 fee for a two-week camp.

R: Would it alright for me say that you spend quite a bit of time and efforts to find these things for your son?

Cheri: Oh...oh of course. There are a lot of resources that parents can get for their children. But you do have to search. Luckily, I do know how to search for info.

In the above, notice how Cheri reveals searching for a wide variety of information; in addition, she claims that these efforts have yielded information which has had a positive impact on her son, and at that the same time has minimized the financial burden on the family. However, she is seen making focused efforts to clarify that not only does she know how to search for information, and also, that it is a laborious process requiring intensive investments of time and patience. Cheri is not alone in her pursuit to seek information from Internet-based sources. Several other parents (n = 8) in this study ascribed to similar views. Consider the following excerpts from two mothers and one father:

Marcia: I love researching a lot of companies and I try to get on the Internet and look to see what is a good field to pursue, and not just one, I go through a whole list of them. He says, “what can I do as an engineer,” and I said, “well they build bridges.” I think engineering and physics are probably the hardest subjects.

Debbie: And I said, to my son, “you’re right, there’s a lot of information out there. And that’s why you gather a lot of stuff, from the evening news, from magazines, and other things from the Internet and just everybody talking. I said, just gather everything together and form your own opinion.” And
that’s what he does, for a 16-year old that’s pretty impressive. But we sit down to talk when he finds something interesting that he likes.

John: I try to research a lot on the Internet. I do a lot of research. I try to look at what companies are hiring, what field they are going towards, what’s fallen down, what’s not being produced. That’s what I was trying to do with my daughter. I was trying to find out what’s a growing field, what’s a good place where you can go and move on and do well for yourself and for the economy.

Combined together, the above instances reveal these parents’ understanding of several characteristics of mass media that can be used to their children’s advantage: 1) extensive amounts of information are available through mass media sources; 2) judicious choices are necessary in deciding which piece of information is worth acting upon; 3) matching their children’s needs to the extensive amounts of available information takes substantive time and efforts. More importantly, many parents in study make claims about breaking the old mold, and separating the wheat from the chaff while looking for suitable information for their children.

Emulating Models of Success

One particularly distinguishing attribute was witnessed in a small group of parents (n = 4). I found that these parents were shaping their selection of resources and interventions based on ‘successful models’ seen among other parents. These parents’ admiration for borrowed ideas was visibly apparent within their expressions and also through the enactment of similarly constructed practices. One such parent was Bethany:

Bethany: Every time, I went to my neighbors’ house, I just found things they were doing interesting. Like I said, to myself, “we don’t do that. My kids don’t do that. I don’t do that.” And year after year, their kids are successful. I am not saying that I mind it… that their kids are more
successful than mine. They are. Our kids are good friends. They are in the science club at school together. But their kids do awfully well.

R: I am trying to understand. Are you able to give me an example that would help me understand what you mean?

Bethany: So last time, I went to their house to borrow some nutmeg, they were all watching a space shuttle take off from somewhere in Florida. Not watching but but watching it on TV. My kids watch reruns of old shows. So I said “that’s interesting, do you always do that?” The dad said “we try.” They are Chinese you know. Did I mention that? The dad said they record things that might have happen during week and watch together on weekend. They even had popcorn out like it was a football game or something.

R: So it made sense for you to borrow these ideas and establish them for your children? So after that what happened at your own house?

Bethany: Not much; though I do try to make sure that my kids know more about things happening in the news…but I did reduce this watching of reruns of sitcoms all the time. So if they want to watch something it has to be like Discovery or Planet Earth.

R: What do you think about this notion when people say, that some parents or parents of certain ethnic backgrounds are pushy and that’s why their children become successful.

Bethany: I don’t think they are pushy. I think they are culturally willing to give 18 years to their children. And I don’t think it’s a case of pushy so much as it’s a case of just not being so selfish…like why can’t we do that in my family. Why is football more important than the space shuttle? And I think that that’s a case of giving up a portion of where you find enjoyment or finding a way to find your enjoyment and having a good time while you are there.

Bethany’s reactions to her kids’ television watching habits are consistent with extant research. In their report: “Generation M: Media in the lives of 8-18 year olds” (2005), the Kaiser Family Foundation found that an average American adolescent spends about 38 hours a week accessing Internet, print media, radio, and television; a significant portion of this time is spent browsing and watching, the Internet and television. Though
not entirely successful, by emulating her neighbors’ routines, Bethany tries to curtail the
time her kids spend watching television. When asked if she had witnessed any changes at
her house, she initially identifies very few. However, on deeper reflection, she points out
a few specific changes, some which are close to the ideas she admires in her neighbors’
practices, i.e., raising awareness of current events, and reducing time spent on watching
eruns of old programs.

It is possible that Bethany’s articulations about the perceived success of her
neighbors’ children and her ensuing desire to emulate their parenting practices are
grounded in frequently circulated theories regarding Asian Americans and the relatively
higher levels of academic achievement. Her repetitive emphases on clarifying the
neighbors’ ethnic background may be indicative of her positive perceptions about the
success of Asian American children in K-12 schools and post-secondary institutions.
Yet, Bethany’s views about her neighbor’s involvement with children as something worth
emulating are in deep conflict with some researchers who postulate that Asian Americans
are relatively less involved with their children in comparison to White parents. Three
more parents, who adopted ‘borrowed’ ideas, chose friends, siblings and acquaintances of
similar social and ethnic backgrounds as their ‘role models.’ Among the parents in this
study who had adopted transformative ideas from acquaintances, Bethany was the
exception in emulating ideas of parents belonging to a different ethnic background.
Summary

Parent participants of this study describe efforts to provide learning opportunities in STEM fields for their boys and girls through the use of several unconventional means including extensive outreach to OST organizations and OST mentors; establishing valuable relationships with acquaintances, colleagues and clients; sidestepping the information obtained from school-based resources; and looking for additional sources of ideas beyond schools and teachers. It is important to note that a few parents demonstrate their simultaneous usage of traditional means of support in addition to exceptional and unorthodox ones adopted more recently.

This study also found that parents plan their efforts by asking careful questions, emulating ‘successful’ practices witnessed among other parents, seeking help from members of social and professional networks, and making focused and sometimes difficult decisions. The perceptions shared by individual parents and students in this study are mostly aligned in spirit with emergent research. More importantly, this study was able to identify several areas of concurrence within majority of participants, parents and their children.

However, the findings of this study are also indicative of a few paradoxes among parents’ understanding of STEM disciplines and their views about effective ways of providing support to their children, and the corresponding efforts required by students. While the broad narrative of this study demonstrates attentiveness and clarity in many parents’ thought processes and ensuing actions, it also exposes a few underlying ambiguities and misconceptions. Fortunately, the latter are few and scattered.
CHAPTER SIX: NEGOTIATING CHOICES, DECISIONS, AND TRAJECTORIES WITH PERSISTENCE

Introduction

Progress in any or all STEM fields can be traced to students’ early achievements and persistence in science and mathematics (Commission on Mathematics and Science Education, 2009; President’s Council of Advisors on Science and Technology, 2010; Simpkins, Davis-Kean, & Eccles, 2006; Zeldin, Britner, & Pajares, 2008). Although a vast body of research regarding the specifics regarding parents’ contributions towards success in STEM disciplines is missing, in general, children’s academic achievements have been closely linked to the formation of positive identities and establishment of goals by parents (Crew, 2007; Eccles, 1994, 2006; Epstein & Sheldon, 2001; Greenfield, 1996; Jodl, Michael, Malanckuk, Eccles, & Sameroff, 2001; Simpkins, Davis-Kean, & Eccles, 2006). To that end, understanding the cumulative effects of parenting practices and development of positive identities among children are critical as these bear considerable influence on students’ exercise of available educational choices (Baumrind 1971, 1989; Conley, 2005, 2008; Dweck, 2006; Eccles, 1994; Greenfield, 1996; Simpkins, Davis-Kean, & Eccles, 2006).

The actions and attributions of parents in this study are revealing of three essential considerations. First, these parents understand that the period of adolescence is associated with increasing autonomy among children. Second, these parents respond to the developmental advancement of adolescents by decreasing their authority and control over day to day care, and yet, remaining vigilant about sudden changes in students’ work
habits and educational trajectories. Third, these parents believe that respectful
relationships with children are likely to bolster the possibility of their advice being
received constructively by children. In this study, the parents’ contributions towards
guiding their children’s academic progress become noticeable within several different
roles ranging from provider to mediator, and from supervisor to coach.

Analysis of all data sources indicates that the parents in this study can be
categorized into several overlapping groups. A large number of parents orchestrate their
efforts by maintaining ongoing conversations and building positive relationships with
children. Others provide assistance within efforts directed towards goal setting and
positive reinforcement of constructive dispositions. Still another group of parents
orchestrated efforts by providing boys and girls with encouragement and strategies for
overcoming challenging situations. A few parents were found using efforts to soften the
harsher stance of gender-based perceptions; and even smaller numbers made claims of
regulating their children’s part-time jobs during weekends and summer breaks. In the
following sections, I have identified five domains through which participant parents used
a variety of efforts, interactions, and interventions to bear influence on their children’s
exploration and participation in STEM fields. Although the identified areas are not
exhaustive in nature and neither is it likely that they disclose the totality of all parents’
efforts, the identified areas provide an insightful representation of the larger group.
Establishing Stable and Positive Parent-Child Relationships

Notwithstanding a few and minor mitigating factors, parents’ and students’ attributions pointed to the existence of reciprocal positive relationships between parents who provide support to their children and students with positive self-identities; these could be witnessed among both genders as well as across diverse backgrounds. Corroborating evidence was also seen in the data gathered from preliminary surveys, revealing that conversational exchanges between parents and children were perceived to be of high impact by both groups (n = 26; 15).

While their only child, Shane was growing up, Jethro and his wife, Elaine, were concerned about his lack of resilience under challenging circumstances, “which would then have impact on his ability to stay on task in classes.” After a great deal of deliberation amongst themselves they decided to “initiate a talk time” that included both parents and their son. During one of two interactions with this researcher, Jethro recalled:

We would all gather in [son’s] bedroom and we had a rocker in there from back in the baby days and somebody would sit on the bed, somebody would sit on the desk chair and we would just sit around and talk about our days and we would take turns and we would just say stuff about what happened at work today. He was always exposed to more detailed levels of what was going on in our lives...What are the challenges mom is facing at work and how is she dealing with them.

Both Jethro and Elaine identified the positive impact of the conversations, and also the significance of their timing: “from early on, before he became embarrassed to share things with his parents, by doing that, I guess, we made it a natural thing to do.” Based on daily observations of their child’s personal characteristics, Jethro and Elaine
made small changes in their household routines which over the course of time sustained his educational progress. From the profound level of satisfaction and positive tone of the affirmations, it appears that Jethro and Elaine were able to realize positive outcomes through the establishment of routinely held candid conversations with their child. The preemptive timing of their interventions and informal structure led to easy acceptance by their son before becoming reluctant to share concerns and challenges with parents. Furthermore, Jethro claimed that their early efforts towards providing emotional assistance are delivering “ongoing results many years later; very positive results, mind you.”

In this study, Jethro and Elaine are not unique in their attributions; over the course of this research, I encountered several other parents, one fourth of all fathers and mothers, who expressed similar views. Among them was Trudy, mother of 17 year old male. Her son, Tony, is a sophomore in a local public school. During her interview, Trudy recalled:

Trudy: We do, we have a lot of conversations. But I also think that it is right not being there with him all the time. It is good. And the fact that when I went to [event 1] last year and [event 2] I never saw him, hardly ever. Which was good, he was happy with that, I’m sure. But when he wants to talk, I am there...And we encourage him too, to do what he likes to talk about.

Trudy attributes her proclivity for “easy talking habits” to her Native American roots and growing up on an Indian reservation, where she “learned that peoples can sort problems by talking things.” Further, she pointed to her son’s relaxed attitude during the school year as a result of “sitting him down and talking with him” to help him out:

Trudy: A sort of an example, hmm, his freshman year in high school he was stressing over it, it was really affecting him. I said, “I would rather you step down from doing this and that.” Well I said “you want to be an engineer,
you want to do well on your math and your sciences courses. If volunteering at church is going to cause you to stress out and affect your class work, I was like we take a step back.”

In the above, Trudy is seen encouraging her son to pull back from the excessive pressure of numerous responsibilities, one of which, according to her is associated with the family’s longstanding social commitments. Through an accommodative and simultaneously assertive process, she is alleviating some of the academic and emotional pressures being experienced by her child. Often, during the period of adolescence, it is not uncommon for parents and their adolescent children to experience unresolved issues regarding school, academic expectations of parents, and children’s growing autonomy; however, Trudy identifies solutions that prioritize her son’s needs ahead of the family’s social obligations. She expressed confidence about how the “tough” actions “built a sense of give and take,” which in turn, led to the establishment of a positive relationship with her child. Sentiments of similar nature were resonant among several other parents’ attributions. Three parents acknowledged that pulling back and easing pressure on their boys and girls were helpful measures towards building strong relationships over the longer duration.

In contrast, at least one student indicated that he desired for something different from his parents. Lorber is a junior in the same school as Tony. His reflections demonstrated marked deviation from other boys and girls in this study:

R: If there was any way to change how your parents do things for you, or help you out or work with your teachers, what would that be?

Lorber: Definitely, I don’t want to say “force” because they don’t force me to do anything, but definitely push me more.
R: You would want them to push you more?

Lorber: Yeah, they push me, but they could push me more if they wanted to.

R: Hmm, that is very interesting. What would happen if they pushed you more?

Lorber: I think that I would get even better grades than I do now. My grades aren’t bad and they know that, so they don’t really put pressure on me to do better when I am still doing good, but I know that I could do better if they pushed me.

By voicing his opinions, Lorber provides an interesting variation of the prevalent understanding that adolescents’ beliefs and choices are integrally linked. Lorber conveys that if “his parents had pushed” him, not only would he have welcomed their assertiveness, he is also, convinced that his academic performance would have been of superior quality. In contrast to Trudy’s son who received stress-free suggestions from his mother, Lorber prefers more emphatic expectations from his parents. On a basic level, the difference between the narratives may be indicative of individual differences among parents and their children. However, a critical look into the respective narratives may also be suggestive of parents’ concerns about placing excessive expectations on their children, on one hand, and children’s appreciation for more rigorous approaches from parents, on the other hand.

Differences in the Relationships of Fathers and Mothers with their Boys and Girls

Periodically, extant research has indicated the presence of marked differences between the abilities of each gender, in turn, which has led to large scale development of stereotypes regarding the academic performance of boys and girls (e.g., Epstein, 1988;
Gurian, 2011). Other researchers argue that the notion of stark differences between genders is mostly unsubstantiated (e.g., Fagot, 2002; Hyde, 2005). An emergent group of researchers claims the differences between boys and girls are not grounded in their respective abilities, rather, within the differential treatments by teachers and parents (e.g., Fagot, 2005; Hyde, 2005).

My research revealed a few instances of parents’ ascription to stereotypical views across children of both genders; however, among the majority, no noteworthy differences could be discerned. Notwithstanding minor differences, for the most part, parents of boys and girls extended similar kinds of support. As a result, no clear pattern could be established within the type or scale of efforts extended by fathers and mothers to their boys and girls respectively in this study. In order to explicate the findings of this study in the context of extant research, below are excerpts from interviews with three fathers; two of daughters and one of a son. Although the following includes excerpts from only three parents, they echo the sentiments of almost two fifths of total numbers.

Case Example #1

Joe: So what do I do at home? Hmm... Give her the opportunities with equipment like computers. She has her own equipment, her own computer system... She’s very inquisitive that way. Then I can facilitate my answers to her questions. She has access to her own computer. She has a laptop now. She has internet access.

R: Do you monitor it?

Joe: In the beginning it was more monitored. It’s less monitored now. I fully trust her at this point. Although I still go back behind her once in a while just to see what is happening.
Case Example #2

R: What did you do when [son] was not performing to his ability? I know that you have told me that you expressed your disappointment, but what did you do beyond expressing your disappointment?

Wolff: Nag. Nagging always works. Yes. But also I think if for example, I think offers of help. If there’s an assignment due or a piece of homework that is due that there is foot dragging on then you can do things like put limits on what they are allowed to do and also offer them assistance. You can say, well I know you have a big project that is due on Monday, I don’t think you have made a lot of progress on it. I know you wanted to go over to so and so’s house or have friends over, you’re not going to be able to do that until you’ve completed your project. And I will help you with your project if you need help, as much as you need.

R: If a child has some type of aptitude for science and then stops expressing an interest in that [field] at some age, can the parent rejuvenate that aptitude and say you know, “what happened you were interested in this, why have you lost your interest?” Can the parent steer them back into the fold of it?

Wolff: In retrospect had I pushed him harder he probably would have gotten into it and enjoyed it and probably would have been beneficial.

R: Some people call that being pushy. Would you call that being pushy?
Wolff: Yea, yea.

Case Example #3

R: In what way do you think [daughter] perceives the value of your support? Do you think that she realizes how much you and [mother] support her? Or even that you want to support her?

Bob: Oh yeah. I think that she knows that very immensely. Her mother is more proactive than I am. Mom gives her positive reinforcement all of the time. And I’m more like a strict guy; I’m kind of tough on her.

The first situation highlights Joe’s supervision of his daughter’s access to a computer and Internet, by providing direct and instructional feedback and close monitoring of his daughter’s online searches. There is a gradual transition within Joe’s
efforts, as he acknowledges an increasing level of trust and confidence in daughter’s ability to use the Internet and make good decisions about what kinds of information to search. Contrary to extant research which asserts that fathers are less reluctant to ease control on their daughters than sons, it becomes apparent that over a longer duration, Joe’s actions are not demonstrative of adherence to gender stereotyping (Fagot, 2005).

The next two excerpts are demonstrative of two fathers’ opinions about their relationships and interactions with a daughter and son respectively. Both fathers, Wolff and Bob reveal an underlying forceful demeanor which guides their efforts for enhancing children’s academic performance through the enactment of “tough” and “pushy” measures. On the one hand, Wolff expresses unyielding perspectives regarding his strong beliefs about “being pushy.” He attributes the changes witnessed within his son as positive outcomes of his “nagging and pushiness.” According to Wolff, had he decided to pursue more insistent goal setting, these may have been well received by his son.

On the other, while Bob recognizes that his wife’s interactions with their daughter are of a more sympathetic kind, he is also cognizant of the anomalous conditions related to his “tough” attitude of parenting a female child. Bob’s comments may be indicative of his beliefs that the foray of adolescents’ into STEM fields requires a different kind of fortitude: “Well, I think in terms of science and technology, that’s the harder curriculum, rather than learning more of the old stuff, kids spending more of their time more toward [softer] curriculum, like English or the arts or sports.” More importantly, during the interview, he asserted that his daughter appreciates this form of support. It is possible that due to his appreciation of the challenges presented by the “harder curriculum” and its perceived necessity for entering the STEM pipeline, Bob has decided to assume a more
demanding stance with his daughter. While admitting that his attitude and interactive style with a female child are "kind of tough," he remains unapologetic for the dynamics of his parenting. Contrary to some extant understandings, in both examples, parent’s forceful expectations are being perceived in positive light by parents as well as children.

Emphasizing Positive Dispositions and Characteristics

Starting from elementary school years, children’s everyday activities and experiences have an inherent capacity to reinforce development of positive beliefs towards science and mathematics (Brickhouse, Lowery, & Schultz, 2001; Ceci & Williams, 2009; Simpkins, Davis-Kean, & Eccles, 2006). For instance, the total numbers and levels of math and science courses undertaken by individual students can be predicted by the strength of their self-identities as learners of math and science (Brickhouse, Lowery, & Schultz, 2001; Simpkins, Davis-Kean, & Eccles, 2006). Furthermore, Brickhouse, Lowery, & Schultz (2001), claim that “if students are to learn science, they must develop identities compatible with science identities” (p. 443). The above findings have strong implications for the STEM pipeline, especially in the case of underrepresented students, enabling them to believe: “maybe [we] haven’t done well historically, maybe we weren’t encouraged, maybe we didn’t believe in ourselves, but these are acquirable skills” (Dweck as cited in Hill, Corbett, & Rose, 2010, p. 33).

Parents’ Orchestration of their Goals to Reinforce Specific Dispositions

Several parents in this study made assertions regarding how they steered their children towards acquisition of specific dispositions. Parents’ efforts can be primarily
seen across two domains: first, raising students’ interest through informal and enjoyable activities, and second, reinforcing the instruction and information provided by teachers and schools. A few parents like Marcia used informal settings to build their children’s knowledge about opportunities in STEM fields, and then, used the newly acquired knowledge to elevate their children’s appreciation for applications of STEM fields:

R: You said that you woke your son up early on a Saturday morning to make this trip? What was your reasoning?

Marcia: Oh yes. Being there and helping him listen, meet people in science, STEM, that’s important, it’s the best way I can think of inspiring him…continuing to excite him, his interest in the field.

R: So you think this is useful?

Marcia: Oh, yes.

Marcia: I have traveled with him to see sights all over the state like unveilings of new labs or the launch of new boat commissioned by the Navy or even the Marine research facility down in [name of town]. I am single parent, I can’t go far or even afford to go far but I am always checking the newspaper or TV to see what is happening. You will be surprised but sometimes my child is the only one there. There are lots of newspaper reporters or other important people, but I don’t see many people bringing their children.

As stated in a previously, it was clear that because of her educational and professional experiences, Marcia had intimate knowledge of STEM fields, especially about the various complexities commonly associated with successful progression in STEM fields. Further, Marcia revealed attempts towards securing access to external opportunities for her son. Marcia’s actions are reminiscent of research conducted by Simpkins, Davis-Kean, & Eccles (2006) who found elementary students’ self-conceptualizations about success in science and mathematics have strong influences on
their identity formation during middle and high school years. Accordingly, Marcia used informally structured activities in order to impress upon her son that science and technology are “not all boring,” instead, belong to a broad spectrum of possibilities. The above attempts are underscored by a desire to facilitate her son’s appreciation for broad applications of science and technology.

In comparison to large numbers of parents who reinforced children’s interests in STEM fields by using OST opportunities, significantly fewer parents utilized educational opportunities available at their children’s schools to accomplish similar outcomes. One such parent was Teri, whose stepdaughter, Leyla, held aspirations of pursuing an undergraduate degree in chemistry. Both, Teri and her husband, were deeply concerned about the young girl’s growing ambivalence and fear of “hard work.” Teri’s accounts also revealed that neither parent had educational or professional backgrounds which were likely to provide any explicit insights into commonly associated challenges of STEM disciplines.

According to Teri, more recently, the lack of any role models or personal connections with women in STEM professions in their immediate social circle had created further doubts in the young female student. In addition, Teri reported that frequently circulated messages like “anyone can do science” or “girls can do science too,” were in fact deterring their daughter from participating in higher levels of science classes because it made her anxious “if science is so easy how come I am struggling?” After talking to a knowledgeable neighbor, Teri decides to raise the issue with her stepdaughter and possibly help her by allaying some misconceptions:
R: If there was one thing you could identify that made a difference, what would it be?

Teri: I have never said that science or math is easy, I tell her that it will take hard work that she should be prepared, that she should not be afraid if things don’t come to her easily. For all that, that it takes hard work. I knew she was nervous because no one in our family has ever, ever pursued this field.

R: How did you make the decision to communicate this message?

Teri: Our neighbor told me to.

Over the next few months, Teri recalls witnessing some clear changes in her stepdaughter: “She became less afraid. We were so relieved. Can’t tell you how much relieved we were.” Advice from Teri’s neighbor was effective from two aspects; first, it resulted in open praise of daughter’s level of success thus far, and second, it provided a candid appraisal of the challenges ahead. The neighbor’s advice likely also filled some gaps in these parents’ knowledge about factors related to children’s successful entry in the STEM pipeline. In retrospect, after resolving the anxieties which were weakening a young girl’s determination to pursue post-secondary studies in physical sciences, Teri admits a deep sense of satisfaction.

*The Underlying Assumptions Guiding the Parents’ Efforts*

The excerpts in the above section clearly demonstrate Marcia’s and Teri’s efforts of raising children’s awareness about the characteristics that are inherent to STEM fields, and highlight some noteworthy similarities and differences. Marcia articulates motivations for taking her son to the local Naval Yard to witness a ship being commissioned for active duty. She aims to bolster her son’s appreciation for wide
ranging applications of science and engineering. Marcia believes that “witnessing an event of that magnitude where people from several STEM professional backgrounds are likely to attend” is likely to act as a strong incentive for her son.

Although Teri and her husband claim minimal familiarity with the academic underpinnings of STEM fields, they have an intuitive understanding of their daughter’s declining confidence, which in turn, they believe is likely to have far reaching consequences on her long-term academic achievements. Given the absence of deep and personal knowledge about adolescents’ participation in the STEM fields, their intervention acquires further importance because it indicates strong beliefs about resolving adolescents’ misconceptions and providing clear information.

While Marcia uses public events to reinforce useful dispositions in her son, Teri, seeks the advice of a knowledgeable neighbor to resolve her stepdaughter’s ambivalence about challenging course work at school. In contrast to Marcia’s premeditated efforts towards furthering her son’s knowledge about opportunities in STEM fields, Teri’s indirect engagement with stepdaughter’s academic progress manifests itself in the context of an emergent need. Teri claims to have limited familiarity with the challenges inherent to the STEM pipeline; however, by following the advice of an informed neighbor, her interventions are closely reflective of extant research. Along with an intuitive understanding of challenges faced by adolescents, Teri also offers unfailing support to her stepdaughter. Her two-pronged process of providing accurate details along with assurances of support is likely to help the young female student in overcoming mounting anxiety about pursuing challenging course work.
Mitigating the Impact of Stereotypes

Frequently, mathematics, computer technology, and physical sciences are seen as ‘masculine’ disciplines, while humanities and biological sciences are identified as ‘non-masculine’ fields (Ceci & Williams, 2007; Else-Quest, Hyde, & Linn, 2010; Halpern et al., 2007; Hill, Corbett, & Rose, 2010; Katehi, Peterson, & Feder, 2009; McCall, 2008). Furthermore, many girls “find their confidence in their ability to succeed in challenging math courses or in a mathematically oriented career undermined by parents’ and teachers’ beliefs” (Hyde, 2005, p. 590). Several researchers identify emergence of ambivalence towards physical sciences among girls as one of the key factors informing gender gaps in the so called masculine STEM disciplines (e.g., Ainley & Daly, 2002; Halpern et al., 2007; Haste, 2004; Perry, Pryzybysz, & Al-Sheikh, 2009).

Enabling the Visualization of Oneself in ‘Masculine’ Disciplines

A few months after Teri and her husband, helped Leyla, understand the characteristics and challenges associated with STEM fields; Teri noticed a new source of ambivalence taking hold of the young girl:

Teri: Originally she was talking about doing more in that field...looking through the microscope and using the different machines that do tests. Then she caught cold feet. She was not excited anymore. [Leyla] said, “Looks like it always is too many boys and no girls.”

After recognizing another sudden changeover, and becoming concerned about its impact on Leyla’s confidence, once again, Teri decided that she needed to take some deliberate action:
Teri: She’s very, very interested in that TV show it’s like Naval something. There is one girl in there that does a lot of investigating. She works in the lab. I forget her name now for the life of me. And I’m like “I can see you being Abby. Abby is the character’s name. You can be in that room checking all of that stuff out.” I remember now, it’s called NCIS.

R: It has been established that girls get steered away from subjects like chemistry or physics because they don’t see themselves being successful in those fields. There are a lot of biases and stereotypes. Were you aware that Amy’s reactions were in response to such beliefs?

Teri: Really? Really? I had no idea. I just could see that she becoming afraid. So I used the TV show example because it was there.

R: Did that change her mind?

Teri: I wouldn’t say it changed her mind, but she started being so fond of “Abby’s work” that she forgot about being afraid.

Though on several exchanges with this researcher, Teri made repetitive claims about lack of direct knowledge, yet, she clearly understands that unless the young girl is able to visualize herself in a field characterized by “too many boys and no girls,” any further progress is quite unlikely. It is important to note that lack of explicit knowledge about gender gaps or of the biases and stereotypes associated with girls’ participation in ‘masculine’ disciplines does not prevent Teri from offering an example of a role model, albeit a fictitious one, to her stepdaughter. It is highly possible that Teri’s actions minimized the possibility of her stepdaughter’s immediate attrition from goals of pursuing higher studies in chemistry.

In spite of her limitations, Teri utilizes simple, low-cost, and easily accessible resources to enable a shift in her stepdaughter’s stereotyped reactions against physical sciences. More importantly, Teri’s efforts represent optimal utilization of the affordances and privileges associated with her social class. She bridges some gaps by seeking help
from a more informed person. Unlike some other parents like Marcia, who had deep knowledge of STEM fields based on personal educational and occupational experiences, neither Teri's educational background nor her occupation as an office secretary are suggestive of access to knowledge or extensive professional networks, and yet she manages to find a feasible solution within the immediacy of her environment.

Limiting Competition from the ‘other’ (Gender)

There are several anomalies amidst the unresolved issues regarding relative effectiveness of mixed gender versus single sex schooling. Some researchers posit that females should strive for gender equality within mixed gender schools, whereas, others claim that boys receive the short end of educational opportunities in mixed gender schools, and still some others state that both boys and girls in mixed gender schools make more stereotyped choices in comparison to counterparts in single gender schools (e.g., Gurian, 2011; Gurian, Stevens, & Daniels, 2009; Sullivan, Joshi, & Leonard, 2010).

In this study, two parents of boys and four parents of girls indicated their respective preferences for single sex schooling. Among the above, one boy and all four girls attend single sex schools. Parents of three female students identified decisions to enroll their daughters into single sex schools in order to limit competition from boys. Connie was one of two parents who went to great lengths for securing single sex private schooling for her child despite the financial strains associated with the choice. Connie claims that her occupation as a delivery truck driver puts her in constant contact with a wide range of clients who have often been crucial sources of information. During my several interactions with her, I learned that her daughter had a strong likelihood of being
first in the extended family to attend college and as a result, Connie was prepared to go to any lengths to turn the vision into reality. This included postponing personal needs and borrowing money from grandparents:

Connie: I can tell you why. Because it has to do with science. She was doing the Science Olympiad and every year she always came in like 3rd, 4th and everybody ahead of her was always a boy. And it used to make her very mad. In 7th grade she elected to do a Jacob’s ladder with all different kinds of lights. She called them conductors. Oh, she made this conductor jump to that conductor in this whole big thing...And after the Science Olympiad was over and they went to go and announce the winners, she didn’t even place. She lost to a plant, to a boy growing a plant...and at that point, she was done. She said, “That was it, I’m not doing it anymore.”

Following is Connie’s response to the frustration her daughter was experiencing:

Connie: My only child! I said “let’s just go check out [name of single sex school].”

R: And then, what happened?

Connie: When we walked out of there, she was good, and she talked to the science teacher there and she said “ok, I really like it here.” It’s all good now.

Several assumptions can be discerned within Connie’s actions and attributions. It becomes clear that she attributes her daughter’s current level of success in a single-sex school because it eliminated “competition from those boys.” However, in her attempts to combat the pressures that she perceives are facing her daughter, she may have avoided paying attention to underlying variables of critical importance. First, she perceives that in the presence of boys and also teachers who pay more attention to boys, her daughter’s self-esteem and confidence are being undermined. Second, within her attempts to combat the stereotypical beliefs surrounding her daughter, Connie perceives that isolating a
female child from male classmates will resolve the concerns. Third, Connie is unaware that beyond the competition presented by boys and “teachers who encourage boys more frequently,” there may be other reasons explaining why her daughter “did not place” at an advanced level in the science competition. It is possible that the misalignment between Connie’s concerns and subsequent corrective actions can be traced to a lack of clear knowledge or reliance on advice offered by clients who may not have complete information about the actualities of the context within which Connie is trying to ensure learning opportunities for her daughter.

Changing the Dynamics of OST Learning

Opportunities for STEM learning exist as much inside classrooms as they do outside of them (Hill, Corbett, & Rose, 2010; Jacobs & Simpkins, 2005; Katehi, Peterson, & Feder, 2009). A key difference between the two learning environments is particularly relevant to this study: while the formal structures of many schools limit parents’ initiatives regarding their child’s learning inside of schools, OST learning opportunities are relatively more advantageous for parents’ involvement by ‘allowing’ a more direct say (Bouillion & Gomez, 2001; Jayratne, Thomas, & Trautman, 2003).

Repeatedly, the data sources of this study, point out that large numbers of the parents included in this study believe in positive impact of STEM OST sites on their children’s learning. This characteristic was resoundingly evident in the accounts of Tonda, one of three black parents who completed the preliminary surveys and one of two black parents who participated in the interviews. Tonda works as a guidance counselor at a K-8 center city public school. Her daughter, Kania, is majoring in mechanical
engineering at a girls’ college. Tonda claims that she was able to discern her daughter’s appetite for science at a young age: “She was always interested in science but everywhere at school, at the Y (YMCA), even some summer camps, she was either the only girl or one of a few.” Over the next few years, Tonda recalled a growing sense of dissatisfaction within her daughter. During a rather lengthy interview, Tonda explained the underlying assumptions of her efforts:

Tonda: So she would start these things, activities with great excitement but then all would be overtaken by the boys or if there was a leadership position, she was made the ‘secretary’ of the group or something. I knew it wasn’t working for her because she went from one science group/activity to another in just couple years.

R: So then what would you say or do to support her interests in science?

Tonda: So so I thought, “Where are there more girls than boys and they do science?” After many discussions with my daughter, I enrolled her in the Girl Scouts group that claimed they did a lot of science and math. Anyway, it was not exactly true but at least she got to see girls doing some (emphasis added) science.

R: How long did this continue? Did your daughter always participate in opportunities that included only girls?

Tonda: No things changed. I, I changed them...She (daughter) saw the [ASE] program on her school bulletin board; we went to see a demo. I remember, we barely made it because I had to get special permission to leave work early and then pick her from school to get there...Anyway, so she joined [ASE] program, here too there were more boys than girls.

Tonda: But see now, by now, it did not matter because she was confident that she could do science, even do engineering. Then, she became fine with that boy girl ratio, like 25 boys and 8 girls.

There are several sequential and important considerations in the above excerpt. First, Tonda becomes aware of the frustration experienced by Kania while negotiating a deep interest in science with a desire for independence. Second, intriguingly, though
Tonda’s attributions suffer from some misconceptions like Connie’s; however, unlike Connie, Tonda bolsters her daughter’s confidence through gradually enhanced opportunities. Finally, just as was witnessed in Connie, Tonda’s actions disprove the widely prevalent understandings that parents undermine girls’ confidence in math oriented activities by lowering expectations.

Challenging Decisions about Children’s Use of Social Networking Sites

The preliminary surveys in this study did not include questions about social networks; however, based on other data sources such as interviews and focus group discussions, compared to all students except one, it appears that less than one fourth of the parents are members of Facebook. Two parents, a boy’s father and a girl’s mother, identified interventions regarding children’s usage of online social networks in order to ensure their children’s continued success in advanced classes. This section, discusses Moira who expressed concerns about her daughter’s captivation with Facebook, and also, Jethro, who revealed directly contrasting views about his son joining Facebook.

After seeing her daughter spend excessive time on the Facebook website, Moira became concerned. And when the conditions continued to linger for an extended period, Moira started keeping track of her daughter’s usage of after-school time that was allocated for completing homework. After realizing that anywhere from two to three hours were being spent on Facebook, Moira decided to take some action:

Moira: Many things she was learning at school, she was excited. She really wanted to do well. But she was having a hard time in keeping up with everything...So one day, I said to her, “let’s see what you do with your time once you get back from school...and let’s be honest about how you spend

34 Facebook is an online social network with membership numbers upwards of 600 million people
time.” She got more frustrated.

Furthermore, Moira claims “I asked her to shut down the Facebook time. Well, she just ran away and banged her door tight.” Though, in the beginning, Moira recalls a great deal of resistance from her daughter, later, she began to detect some adjustments:

Moira: She comes down and says, “you know, you are right, I do get lost on Facebook, but many of my friends are there, we just keep chatting. If I am not there (on Facebook) I won’t know what’s happening, I will be left out.” We discussed what was more important, staying with science activities, taking hard classes or what. She decided to deactivate her Facebook account and “see how it would work.”

As Moira “pounced on the chance” to help her daughter make “more sensible use of time,” she was simultaneously concerned about the impact on her teenage daughter as a result of “shutting down” opportunities for socialization with peers. Moira acknowledged her dilemmas and revealed later offers of compromise:

Moira: But I could see that she was afraid that she would have no friends anymore. I said, that I knew chatting with friends was important to her but how about once a month I let her have friends over for sleepover or something.

Through the above process, Moira claims to have achieved two goals: “I could keep her focused on like math that requires many, many hours of hard work, and also keep her from hating me because I prevented her from chatting with friends.”

In contrast, Jethro was delighted to learn that his son had joined online forums including Facebook and another discussion group related to computer technology, and further, explicated his reasons as following:

Jethro: Another way we have helped him out is by allowing him to do this stuff online… He just kind of likes to be the expert…It’s not like he doesn’t
talk to anybody or that he is getting in fights. He seems to be content with who he is. Let him be who he is.

Jethro: With the computers, that seems to be what he is interested in. Let him be who he wants to be. He learns a lot too through that online stuff. He talks to other kids. You know kids of his age who are interested in that kind of stuff. Like what did he find the other day? It was Time Machine software. He just studied it in class, at school, and now through the discussion got to know all of intricacies of how it worked. He just liked the idea of knowing all about it. He tells me and my wife what he is learning.

There are two noteworthy aspects in the above narrative. First, Jethro is able to discern that a new topic in technology is likely to require intensive explorations which are better served by collaboration among peers. Second, Jethro understands his son is reticent about physically getting together with other adolescents, and sees social networking sites as a way for his son to seek more extensive knowledge in a collaborative space. It is noteworthy that Jethro does not specify any efforts towards facilitating his son’s in-person interactions with peers which some researchers also identify as effective strategies for developing collaborative ideas.

Based on their discrepant opinions, Moira dissuades her child from venturing into social networking sites, whereas, Jethro actively encourages it. Although individually both Moira and Jethro claim that their respective efforts ‘made’ their children into high achievers, the underlying assumptions regarding online social networks are completely unlike each other’s. While Moira emphasized attempts to curtail her daughter’s participation in web-based social activities, Jethro made active efforts to encourage his son’s participation in online forums. Moira views tools of social networking as impediments to her daughter’s academic achievement; Jethro sees positive value in his son’s interactions with other youth and the resulting sense of empowerment. Both are
aware that active participation in social networking sites can be a time consuming process; both identify awareness of this characteristic as underlying reasons of their respective actions. Finally both parents are aware that advanced courses in science and mathematics require extensive efforts.

Choices, Balancing Acts, and Trade-offs

Part-time jobs during summer breaks are often understood as rites of passage among American youth (Picklesimer, Hooper & Ginter, 1998). Often, many youth claim that part-time jobs provide them with opportunities to identify future academic and occupational pathways (Cleaves, 2005; Holden, 2010).

In several cases encountered in this study, parents facilitated children’s part-time job opportunities; moreover, a few parents viewed the facilitation of part-time jobs as key turning points in their children’s academic trajectories. According to this small group of parents, part-time jobs were instrumental in either steering or deterring their boys and girls from exercising specific choices influencing current and future academic pathways. Among the parents who viewed summer jobs as valuable learning opportunities for their boys and girls, Stockton held a rather unique perspective. An adoptive parent of Asian background, he communicated a desire for enabling a sense of independence in his daughter. Simultaneously, he expressed strong concern about the possibly undesirable outcomes of his daughter’s potential acquisition of “small incomes during summer:”

Stockton: I don’t necessarily have an issue with her working like during the summer. I think that’s fine. That’s good. A couple times, she brought up about a temporary job, one was dishing out ice cream. I said to her, “I have nothing against that, yea, ok fine,” but, but I was worried.
R: Could you please explain the reasons for your concerns?

Stockton: All I have seen my neighbors’ kids do when they get some money in their pocket is “hang” and “chill.” I was afraid that she would not study much or just learn to hang out with friends. So I said to her, “Find a job at a bookstore.” Well she couldn’t. Well, she wasn’t too thrilled, but then she finally settled down. And that was it.

Because his daughter was unable to secure a part-time job tailored to his specifications, Stockton believes it allowed enabled more unoccupied time at home. Furthermore, during that summer his daughter began to consider different post-secondary options and used the free time resulting from not having a summer job for planning purposes:

Stockton: That summer, because she now, we had time on our hands. You see ‘cause all her friends were working. Who to hang out with? We talked about colleges, and what she wanted to do. And what courses she should take. I let her talk to my boss; he has been through this with his children. I think that was the summer she decided that she wanted to study biology.

Several intriguing aspects can be seen in the above narrative. On surface, Stockton indicates agreement with the idea of his daughter taking up a part-time summer job. However, on deeper investigation, he reveals using tactics to minimize his daughter’s chances of acquiring such an opportunity. More critically, by taking the above actions, Stockton believes that he was able to achieve two goals. First, he was able to prevent his daughter from getting distracted by excessive social interactions; second, he views that these actions enabled a time for candid conversations with his daughter. He believes these conversations were vital factors that led to his daughter’s decisive actions.
A Summer Job in Lieu of an Advanced Course in Mathematics

In comparison to Stockton, Steve’s efforts to shape his son’s work experiences during the summer are grounded in entirely different beliefs. At the time of the interview, Steve’s son was a sophomore in a public school. Steve recalled his son’s struggles as well as some unusual ways of dealing with the challenges. After seeing his son struggle with advanced level mathematics, he agreed to his son’s transition into a lower level class. However, Steve’s consent for the above change was accompanied with a condition: “I encouraged him to seek a summer job that was based on doing math.” After some consideration, Steve’s son signed up for a book-keeping job at an establishment selling gardening supplies. “There was a lot of calculator stuff, he got to do math every day.” In Steve’s perspective, the transition from an advanced mathematics course to a part-time job went more smoothly at home with his son than among teachers and friends. He shared vivid recollections of the disapproval received from friends, and especially his son’s teachers, but expressed few regrets of his own:

Steve: You know, I had people saying: “you’re making a mistake. You’re letting him quit.” I said: “I don’t really see it that way...he gets very tense and stressed out when he even thinks about going to the class.” I would have the same conversation if it was a different class, it just happened to be that one.

R: Did you talk to his teachers before you recommended the tradeoff to your son?

Steve: Well no. I just thought to myself. I know that you can’t let your child take the easy way out. But if your kid has a tendency to be good at math and they get into high school where it is a little harder and they don’t have someone at home to help them or help them get a resource to help them. Then what could I do?

R: Did the trade-off help?
Steve: He was like yea. It made a big difference between his first and second year (in high school).

Although in retrospect, Steve realized teachers were providing well-intentioned advice, he conveyed confidence in ignoring their recommendations. Further, his instincts were proven correct in the following year when his son enrolled in the advanced level mathematics class that he had dropped previously. Not only was Steve confident about the decision, he felt validated because of the “positiveness of those efforts.” The transition into a lower level mathematics class accompanied by a job immersed in mathematical computations provided his son with higher confidence for the following year. The initial responses of Steve’s friends and his son’s teachers are clearly suggestive of their knowledge regarding the importance of higher level math classes. Steve’s efforts reveal a series of complex negotiations: his ability to locate the cause of his son’s discomfort; overlook doubts expressed by well-intentioned friends and colleagues; determination to ward off criticism; take corrective action that is temporarily regressive; and confidence that a math intensive summer job may be helpful in alleviating an adolescent’s anxiety about an advanced course in mathematics.

Summary

According to Holden (2010), extant literature has “portrayed children’s development as occurring along trajectories or pathways,” (p.1); however, it has not been sufficiently attentive to unraveling parent-child interactions that influence the children’s progress towards specific pathways or choices. Five discrete domains distinguish the efforts of parents in this study. These include establishing strong and stable parent-child
relationships; emphasizing development of dispositions and characteristics that are useful for success in STEM disciplines; combating stereotypes; using online social networks to create breakthrough advantages for their children; and making challenging decisions driven by complex and intertwined balancing acts and trade-offs.

To achieve the above end results, the parents in this study are witnessed making conscious efforts to steer their children towards specific goals, look for opportunities within the immediacy of their personal scope, and seek the advice of people from different walks of life. The findings of this chapter are worthy of attention because they disclose several instances of expected outcomes that manifest as a result of positive parenting practices, and just as many that are resultant of some unusual interventions implemented by these parents.

The findings in this chapter are also significant because they unravel the persistence with which these parents assume responsibility of providing support for their children’s progress in the STEM pipeline. The unique combination of numerous pronounced commonalities as well as a few unbridgeable differences emerging from within the participants’ narratives represents a vital essence of this chapter.
CHAPTER SEVEN: CONCLUSIONS, IMPLICATIONS, AND POSSIBILITIES FOR FUTURE RESEARCH

Introduction

This investigative study was focused on unraveling the range and variation of resources used by parents to support their children’s participation in the STEM pipeline. The primary research question guiding this study was: “How do parents support their boys and girls for participation in the STEM pipeline? What is the range and variation of support given by fathers and mothers to their children for entering and exploring STEM fields?” The overarching goals of this study were to: 1) acknowledge that amidst the large scale goals of generating a robust STEM pipeline, current endeavors have not paid sufficient attention to potential contributions of parents; 2) draw upon parents’ and children’s narratives in order to identify the ways through which parents provide support and ascribe meanings to their efforts; and 3) discern the underlying commonalities within parents’ and children’s attributions and locate recurring themes.

During the investigative processes encompassing this study, I have focused on expanding the current research regarding the STEM pipeline and parental involvement, first by highlighting the cross connections between the two tenets of extant research as they apply to the research questions, and second, by looking at the critical junctures where individual narratives of the participants resonate or digress from current understandings. Further, I have made consistent attempts to locate commonly visible patterns among parents from diverse backgrounds, whose backgrounds indicate
comparable levels of access to resources and useful relationships, and also among those
who demonstrate differential levels of access to the above elements.

Understandably, the narrow research timeline limited the level of attention which
could be focused on myriad themes emerging in this study. Since it was nearly
impossible to do justice to all emerging possibilities, I had to make strategic decisions to
explore a few essential and apparent themes, and simultaneously, make note of other
intriguing aspects and put them on hold for future research. As discussed in preceding
chapters, the research questions guiding this study were probed through several rounds of
data analysis. In presenting the findings of this study, I have focused on a three-fold
emphasis: 1) the accounts shared by individual participants have been used to develop
new insights; 2) findings of this research study have been situated within extant literature
including several widely circulated and renowned legislative reports and research studies;
and 3) emerging insights as well as unresolved issues have been used to frame
implications for a wider constituency and propose suggestions for further research
studies.
Conclusions

Three intertwined sets of conclusions represent the emergent insights of this study. As explained previously, this study was conducted among parents and students whose common identity reveals access to shared information and ideas. First, I posit that these parents’ efforts can be conceptualized through a system of “AID: Adaptive, Incidental, and Deliberate Practices” representing a wide range of choices, decisions, motivations, actions, and interventions used by parents to prepare their children for the STEM pipeline. Second, the study reveals parents’ efforts within a pattern comprising several notable and evolving transitions, beginning from children’s early childhood years and lasting into high school. Third, in spite of several demographic differences across race, ethnicity and social class, and gender of child, the parents’ efforts are underscored by a unique combination of notable characteristics.

*AID: An Emergent Model Explicating Parent’s Efforts*

Based on the findings of this study, I posit that the totality of efforts comprising these parents’ support for their children’s participation in the STEM pipeline can be viewed through a structure of “AID: Adaptive, Incidental, and Deliberate Practices.” Figure 7.1 illustrates the distribution of Adaptive, Incidental, and Deliberate Practices among fathers and mothers included in this study.\(^{35}\)

\(^{35}\) Singular examples were not used in this classification
Figure 7.1: Distribution of Parents’ Efforts across Adaptive, Incidental, and Deliberate Practices

<table>
<thead>
<tr>
<th></th>
<th>Adaptive</th>
<th>Incidental</th>
<th>Deliberate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal Learning</td>
<td>F/M</td>
<td>M &gt; F</td>
<td>F = M</td>
</tr>
<tr>
<td>Spatial Skills</td>
<td>-</td>
<td>F = M</td>
<td>F &gt; M</td>
</tr>
<tr>
<td>Formal Learning</td>
<td>M &gt; F</td>
<td>-</td>
<td>F = M</td>
</tr>
<tr>
<td>21st Century Skills</td>
<td>F = M</td>
<td>-</td>
<td>M &gt; F</td>
</tr>
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F = Fathers; M = Mothers

Adaptive Practices are understood as actions and interventions implemented by parents based on ideas emulated from personal or professional acquaintances, including modifications of the ‘borrowed’ ideas. In contrast to Incidental and Deliberate Practices, parents owe the conceptualization of efforts included in this category to persons other than teachers or OST mentors. As such, Adaptive Practices mostly include parents’ efforts to emulate the ideas or actions seen elsewhere among other parents.

The key to parents’ incorporation of Adaptive Practices is their focus on specific elements perceived to yield immediate impact. It was consistently seen that in contrast to
Incidental and Deliberate Practices which were spread over longer time periods, Adaptive Practices were utilized for short durations. Additionally, Adaptive Practices were often witnessed within the parents’ precipitous reactions to resolve spur-of-the-moment requirements, and mostly put in effect during children’s middle and high school years.

I found more mothers than fathers (n = 6; 2) used Adaptive Practices for implementing changes in children’s formal learning opportunities like course selection and sequence; however, approximately equal numbers of fathers and mothers (n= 3; 4) made use of Adaptive Practices for fostering 21st Century Skills among children. No clear instances of Adaptive Practices could be discerned in parents’ efforts towards facilitation of informal learning and spatial skills. It is also plausible that some parents were unable to recall the use of Adaptive Practices during their children’s formative years because over time these got embedded in everyday routines, and then, got lost within these parents’ recollections and attributions.

Adaptive Practices present a noteworthy discussion because though it might be reasonable to infer that implementation of ideas without any foundational understanding of the processes or goals are unlikely to yield any positive results; however, at least in a few instances, this was found to be not true. Additionally, a few times though not frequently, ‘borrowed’ ideas were utilized by parents in this study without consideration of the actual context or attention to their children’s specific needs, rather, in response to positive outcomes witnessed elsewhere. In spite of the extenuating factors, many of these parents realized positive outcomes after utilizing Adaptive Practices. For instance, by

\[36\] The significance of these numerical distributions changes slightly if the proportionate numbers are taken into consideration because this study included more mothers than fathers
emulating a neighbor whose children watch telecasts of scientific events, although Bethany was not able to replicate the exact outcomes seen at neighbor’s house, it leads her to conclude that too much time watching commercial television shows may be limiting her children’s ability to focus on more constructive tasks.

I define Incidental Practices as age appropriate learning activities promoted by parents among children within daily home-based routines. Data analysis revealed presence of a large group of parents who fostered skills considered essential for success in STEM fields; these parents provided toys and common household tools to encourage the inculcation of STEM specific skills in the routine course of daily interactions taking place at home. Notable examples within this category include facilitation of spatial skills, often, considered as prominent indicators among successful STEM entrants. Further, according to several students, everyday exposure to spatial skills by their parents led to the development of abstract mathematical thinking during middle and high school years.

An important characteristic of Incidental Practices is that they were quite likely implemented by parents, possibly before discerning their children’s predispositions towards STEM fields. It is also probable that parents would have implemented Incidental Practices whether or not their children’s expressed interest in STEM fields. Unlike the orchestration of Adaptive and Deliberate Practices which are seen across several settings, parents recall use of Incidental Practices predominantly within home based efforts. Also unlike Adaptive and Deliberate Practices, parents’ efforts under this category are implemented spontaneously and structured with little consideration to any specific kinds of outcomes. Most interestingly, the involved efforts were such integral and essential
components of these parents’ child rearing practices that a few of them were able to recall
details only after considerable probing by this researcher.

The Incidental Practices reveal noteworthy distribution among fathers and
mothers. More mothers than fathers (n = 10; 2) recalled implementing informal learning
opportunities through use of everyday practices; the large gap in these numbers can be
easily understood within frequent views regarding mothers as primary providers of child
care. In contrast, approximately equal numbers of fathers and mothers (n = 5; 4)
demonstrate use of Incidental Practices towards development of spatial skills among boys
and girls. This study was not able to identify parents’ efforts within Incidental practices
across formal learning and 21st Century skills; possibly because the last two categories
manifest during later years of children’s progress.

Finally, I describe Deliberate Practices as the planned and structured
implementation of initiatives by parents based on underlying foundations of informed
knowledge. Out of the three categories, Deliberate Practices were seen across widest
range of activities. Included within this category, are mathematical and spatial skills
fostered by parents among their children as seen in chapter four; and parents’
determination to seek STEM learning opportunities outside of school and leveraging
expertise of professional acquaintances, as discussed in chapter five. Deliberate Practices
were also witnessed in parents’ orchestration of their children’s social networks in order
to have direct and forceful input on the selection of courses or extra-curricular activities,
as seen in chapter six.

Approximately equal numbers of fathers and mothers provide support for their
children’s informal (n= 9; 11) as well as formal learning (n = 9; 7) through the use of
Deliberate Practices. More fathers than mothers (n = 8; 3) lean towards the development of their children’s spatial skills, whereas more mothers than fathers (n = 2; 0) are attentive towards facilitating their children’s 21st Century skills.

I see the above emergent structure and classification as a promising outcome of this dissertation—providing a different way for conceptualizing the underlying bases of parents’ efforts. What makes the above structure of classifying parents’ efforts noteworthy? If we can figure out the short and long term impact of each category of practices, we may also learn how best to advance parents’ capacity to support their children’s progress within the STEM pipeline.

A Visible Pattern of Noteworthy Transitions

The second set of conclusions emerging from this dissertation is that by establishing an early start, these parents assume responsibility for shaping the boys’ and girls’ formative introductions to STEM fields, and then, encouraging perseverance within the STEM pipeline. Throughout the data collection processes, it became apparent that parents made efforts towards facilitating wide ranging skills, knowledge and dispositions among their children starting from elementary school years and continuing through high school (See figure 7.2).
Starting from the incorporation of informal learning opportunities through facilitation of 21st Century skills, these parents’ efforts indicate several noteworthy transitions. During their children’s formative years, parents enhance informal learning through the use of simple and playful opportunities, such as cooking, making crafts, and solving puzzles. Examples can be seen within Olive’s efforts who claims that the willingness to allow “messy things on her kitchen floor” prepared her son for more arduous laboratory exercises during middle and high school years. Approximately two thirds of the parents in the study recalled efforts of similar magnitude during their children’s early years.
As can be seen in the trajectory represented in Figure 7.2, parents’ emphases on fostering the development of spatial skills emerges next. Parents such as Cliff and Dave demonstrate use of activities involving sketching, modeling, and building to facilitate understanding of rotation, geometrical shapes, and numerical conversion among their children. The large numbers of parents’ attention towards facilitation of spatial skills in this study is significant because in recent times, spatial skills are being perceived as the most prominent indicators of success in STEM fields; especially within physical sciences, which typically experience the highest rates of attrition. Furthermore, in contrast to extant research indicating the inclusion of some spatial skills in high schools’ curricula, these parents reveal concerted efforts in this direction during earlier time periods. More importantly, approximately three fourths of parents in this study demonstrate at least some level of targeted efforts towards developing their children’s spatial skills. The presence of this attribute among accounts of large numbers of parents may explicate the already high levels of success demonstrated by their children.

During middle and early high school years, one half of all parents’ efforts become visible within formal learning structures in the form of guidance about course selection, sequence of courses etc. Some parents advocate for advanced level of classes, while others relax their expectations, and still others, devise compensatory learning opportunities in lieu of advanced classes. During the last two years of high school, yet another shift is seen among some parents. In comparison to the other phases, smaller numbers of parents are attentive towards introducing the benefits of team work and shared goals to their adolescent children.
Alongside, the evolving emphases within parents’ efforts, the resources used by parents, experience corresponding changes as well, such as the use of household tools and craft supplies during elementary years to espousal of shared tasks during high school. The transitions within parents’ efforts acquire collective importance because they speak to these parents’ capitalization of children’s age appropriate abilities through optimal utilization of available resources and information.

The Underlying Characteristics of Parents’ Efforts

The final set of conclusions emerging from this study claims that these parents demonstrate some unique characteristics, some of which may appear to be paradoxical on first glance. On the one hand, these parents make concerted efforts, sometimes marked with unrelenting vigor to support their children’s educational progress. On the other hand, they demonstrate flexible approaches by receding from previously determined pathways such as course selections, seeking advice from unexpected sources, conceding when in error, and modifying the shape and delivery of their efforts based on information acquired from external and unconventional sources. Often, the parents’ persistence borders on “pushiness” as inferred from parents’ and students’ attributions. However, neither do these parents express any doubts about the characteristics guiding their efforts, and nor do majority of students.

Additionally, from these parents’ recollections about various underlying processes, it becomes apparent that many parents have an intuitive knack or direct knowledge about skills associated with children’s foray into the STEM pipeline, whereas others follow the advice of personal or professional acquaintances. Yet another group
includes parents who have undertaken steps aligned with extant research without an awareness of the underlying significance of their efforts. As such, these parents are unified by yet another common denominator, i.e. their determination to advance their children’s entry into the STEM pipeline.

The final set of conclusion, points to parents’ focus on steering children’s educational outcomes first by recognizing the obstacles undermining their children’s aspirations or level of confidence, and then, by recommending alternative ways of overcoming challenges. The unique characteristics of these parents’ efforts are worthy of further attention because these are demonstrative of parents’ use of unconventional resources and the swiftness with which make changes to existing dynamics. It is critical to note that the tenacity of these parents’ efforts is primarily driven by their children’s self-proclaimed interests.

Implications

The research conducted for this study has strong implications for parents, youth, educators, parent advocates, and education policy makers. Given the scale of attention that is being focused on strengthening the STEM pipeline, this dissertation offers valuable insights which can be organized into four essential groups, each with strong potential for transference to a wider audience and for broader usage.

Recognizing the Significance of More Similarities than Differences

Contrary to my initial supposition, the differences between the support given by parents to boys and girls were minimal in nature. Though some differences were
discerned in the ways fathers and mothers of boys and girls made use of resources
towards supporting their children’s interest in the STEM pipeline, these differences paled
in comparison to the numerous similarities seen across the actions and attributions of
fathers and mothers. Instead, noteworthy similarities were seen in the resources as well
as resourcefulness utilized by these parents to instill wide range of skills, knowledge, and
dispositions associated with STEM fields among children.

Additionally, this research study included parents from a mix of middle class and
working class backgrounds. While the study was not able to resolve whether the
deavors parents of working class and middle class backgrounds resulted into
comparable outcomes, and neither was its intent to do so, the findings of this study belie
the stereotypical beliefs that exist regarding parents from working class or minority
backgrounds. Stereotypical generalities have especially been constructed regarding
working class minority parents, and are often entrenched in the psyche of educators on
one hand, and also among the concerned students and parents themselves on the other
(Crosnoe & Schneider, 2010; Pattillo, 2008; Ream & Palardy, 2008; Kao & Turney,
2005). Yet, in this study, only minor differences were seen in the ways through which
study participants from middle class and working class backgrounds demonstrated
various ways of supporting their children.

In addition, the implementation of Adaptive, Incidental, and Deliberate Practices
were mostly witnessed across an even distribution among parents from diverse
backgrounds. However, it is important to point out that although parents from mixed
SES backgrounds made similar kinds of attempts to optimize use of available resources,
parents with higher access to relationships, resources, or information displayed slightly
more advantages that could be discerned within their individual attributions. Instances of social class differences emerge primarily in minor details. This becomes important in the context of extant research which indicates that SES and social capital are highly correlated, and furthermore that parents of higher SES are able to garner more advantages for their children by virtue of their increased access to social capital and superior social networks. Based on what can be surmised in this study, that may not be entirely the case under many circumstances.

Redirection of Current Initiatives

So far, the role of parents has neither been enunciated in clear terms nor has it been integrated into large scale efforts implemented in individual schools or within the wider educational context (Commission on Mathematics and Science Education, 2009; Committee on Science, Engineering, and Public Policy, 2011; Hill, Corbett, & Rose, 2010). If we are to believe that “influencing parental effort is certainly something that is much easier than modifying their social background” (Fraja, Oliveria, & Zanchi, 2010, p. 2), then, the findings of this dissertation provide a good place to begin making changes within the current dynamics. The findings of this study beckon educators and policy makers to redirect efforts for overcoming the challenges of a shrinking STEM pipeline by explicitly including parents in the developing initiatives. For starters, a discussion about how parents can be provided with more resources, knowledge about learning opportunities within schools, OST organizations, and post-secondary institutions as well as strategies for overcoming challenges may be useful for all stakeholders.
Multiple rounds of data analysis reveal these parents’ efforts were highly accentuated during early childhood years; among boys and girls; and mostly underscored with similar kinds of characteristics. This study revealed that overwhelming numbers of parents discerned their children’s interest in STEM fields from early on and provided support for children during elementary school years. This specific characteristic among these parents was perceived in sharp contrast to some recent studies that have explored development of STEM specific skills and knowledge during high school years (e.g., Commission on Mathematics and Science Education, 2009; Hill, Corbett, & Rose, 2010). Successful outcomes achieved as result of these parents’ early interventions suggest that the timeline during which it is critical to foster STEM readiness among individual youth may have been miscalculated. Instead of placing overwhelming emphases during last few years of K-12 schooling, the findings of this study indicate that a substantive thrust of efforts during elementary school years may be more beneficial.

The above understandings lead this researcher to propose that a dedicated allocation of resources towards enabling parents’ knowledge about various means of entry into STEM fields is likely to reap favorable results over a longer time period. The data collected from the focus groups alone, suggests positive outcomes can be realized by establishing support groups for parents of similar age children. Establishing similar support groups to direct parents’ attention to the importance of STEM topics in specific, as well as offer suggestions regarding how parents can provide support for their children’s education in general may be useful and vital.
Inclusion of Parents’ Voices in K-12 STEM Education Policy

Two other considerations of deep significance have emerged from the collective voice of parents included in this study. First, parents’ efforts and attributions exposed a dominant critique of schools and curricula. Second, the long term prognoses of the children included in this study remain to be seen; however, their achievements give reason for believing that the endeavors initiated by these parents have been working so far. In consideration of the Commission on Mathematics and Science Education’s recommendations for every child to become “STEM-capable” (2009, p. 2), the findings of this study provide essential ideas that need to be brought to the immediate attention of educators, funding organizations, and policy makers devoted to STEM education.

Based on the above arguments, an important takeaway message of this study is the need for reorganizing institutionalized efforts of formal and informal educational organizations towards coordinated agenda of providing STEM learning opportunities for elementary school students. Not only do these parents identify existent gaps in school-based curricula and preparation levels of school personnel for promoting meaningful opportunities for STEM education, their narratives illuminate a collection of feasible ideas and strategies. Inclusion of these parents’ voices in STEM education policy and recommendations is likely to revamp current understandings and establish new guidelines for schools and teachers.

Parents’ Positioning within Children’s Peer Relationships

The final implication of this study emerges from within parents’ engagements with their children’s peer relationships and participation in online social networks, and
utilization of the embedded efforts for bolstering learning opportunities for children.
This final implication merits attention because it alters conventional knowledge which
states that adolescent children pursue peer relationships independent of parents’
influence, and that parents are just as likely to lean away from day to day conversations
related to friends (Crosnoe, Cavanagh, & Elder, 2003; Kakihara, & Tilton-Weaver,
2009). However, parents included in this study have demonstrated ingenuity by using
children’s peers as confidantes, co-participants, and support systems for their children.
Additionally, parents’ actions have built camaraderie, increased confidence, and
combated stereotypes in their children’s immediate learning environments by influencing
children’s peer relationships and participation in online social networks (Correll, 2004;
Crosnoe, Cavanagh, & Elder, 2003). More importantly, majority of adolescents in this
study acknowledge their parents’ actions with approval and gratitude.

Amidst the extensive use of Internet-based communication tools by youth, the
above insights can potentially assuage parents’ concerns about limited input, and
simultaneously increase students’ proclivities to seek parents’ advice without fear of
excessive interference. However, there is one caveat worthy of mention. Although
several parents in this study demonstrated active engagement with their children’s peers
and peer relationships, there is sufficient evidence that suggests these parents did not
weigh influence on the selection of peers rather only attempted to optimize the existing
relationships.

Instead of succumbing to traditional adages that accept the existence of widening
gaps among adolescents and parents; the findings of this study offer reasons for
bolstering the opposing view (Crosnoe, Cavanagh, & Elder, 2003). Adolescents, parents,
and parent advocates stand to benefit from the insights of this study. These may be especially valuable for identifying parent-adolescent relationships in an environment increasingly dominated by social media tools. Clearly, this was an adjunct finding among a small group of students; however, it makes for a strong case for conducting additional and more focused research in this area.

Future Research: Directions and Methodological Considerations

One of the essential objectives of this exploratory case study was to establish guidelines for further investigations of parent involvement within broader goals of strengthening the STEM pipeline. To that end, several ideas with strong prospects for future research have emerged throughout this dissertation. These emergent ideas can be grouped into three key categories: demography of research sample, multiple perspectives, and research methods.

Demography of Research Sample

1. Differential Age Groups

The study participants make frequent references to parents’ propensities towards establishing interventions for their children during elementary school years. However, during the time this research was conducted, the participating children were in high school, of ages 14-19. It is possible that over time parents’ and children’s recollections have undergone modifications as a result of which they may have been challenged in relating past events with accuracy. Since the significance of parents’ early interventions has
emerged as an important implication in this study, it could benefit from a deeper probe. Therefore, conducting a parallel research study among elementary school children and their parents may be beneficial for providing a deeper understanding.

2. Multiple Groups

This dissertation included parents and children characterized by a common identifier, i.e. their close association with the ASE program, a STEM OST program with a remarkable track record. An exploration of the embedded influences of a common identity may prove to be especially useful for understanding how participants benefit from a common identity, what they learn from each other, and for nullifying the effects of a common identity on their respective attributions. Therefore, future studies can benefit from including multiple groups of parents whose children may have similar inclinations towards pursuing STEM fields but differential access to OST learning opportunities and proximity to experienced and motivated mentors.

Given the current dynamics of the STEM pipeline which demonstrates uneven participation across racial, ethnic, SES, and geographical characteristics, future research studies should continue investigating the myriad factors which bear influence on the participation of youth in the STEM pipeline.
3. Geographical Diversity

The primary site for this dissertation was located outside a cosmopolitan area in the northeast corridor of the United States where large numbers of businesses, universities, and governmental and non-governmental research organizations are focused on STEM education. It is possible the presence of large number of institutions with similar agenda bears significant influence on participants’ views about the importance of STEM fields. Selecting participants or groups of participants from diverse geographical locations is likely to provide a rich context for further studies.

4. Immigrant Populations

A small numbers of participants in chapters four and six refer to immigrant parents in terms of their knowledge and perspectives regarding the importance of STEM fields. Current literature identifies the dominant existence of global regions with differential levels of proven success in promoting STEM education (e.g., American Association for Advancement in Science, 2006; Committee of Economic Development, 2003; Committee on Science, Engineering, and Public Policy, 2011; Hill, Corbett, & Rose, 2010; President’s Council of Advisors on Science and Technology, 2010). Accordingly, comparative research studies that include immigrants from countries with successful track records in STEM education and from those where STEM education is not prioritized as of yet, may be advantageous for unraveling the combined impact of cultural, social and economic factors on parents’ efforts and attributions.
Multiple Perspectives

1. **Teachers and Counselors**

   Throughout this dissertation, numerous references have been made to parents’ perceptions about the contributions of school teachers and counselors towards providing useful information about various aspects of STEM fields. While some parents acknowledged receiving meaningful assistance from teachers and counselors, others expressed indifferent sentiments, and a few shared austere words. As a result, it was largely unresolved whether or not these parents found school personnel’s knowledge or contributions worthwhile. Since teachers and counselors play important roles in the K-12 education of youth, it would be useful to draw on their reciprocal perceptions regarding the contributions of parents towards supporting children for the STEM pipeline and how they can provide assistance to parents for accessing meaningful information.

2. **Mentors at OST Sites**

   OST sites are generally assumed to have significant impact on children’s learning opportunities; it becomes just as important to collect the perspectives of OST mentors regarding the range and variation within which they witness parents’ roles in channeling and supporting children’s entry into the STEM pipeline (Bell et al., 2009; Hill, Corbett, & Rose, 2010). Tapping into yet another key group of stakeholders engaged in the expansion of the STEM pipeline has the supplementary advantages of exploring perspectives guided by an informal stance of education (Basu & Barton, 2007). In addition, a
study that allows for simultaneous investigation of all three entities: parents, school personnel, and OST mentors may lead to a deeper understanding of respective perceptions of each contingent regarding the other two.

Research Methods

1. Longitudinal Study

This dissertation was conducted over a seven month duration during which several data sources were collected. As noted previously in this chapter, based on the findings, the activities and interventions initiated by parents were categorized into Adaptive, Incidental, and Deliberate (AID) Practices. Conducting a longitudinal study may illuminate the long term impact of parents’ efforts across the above three categories. Furthermore, a focused attention on the period of transition between high school and post-secondary education may be especially useful because usually large numbers of students experience attrition from the STEM pipeline during this time (Eccles, 2005; Jacobs & Simpkins, 2005).

2. Random Sampling

Slightly over half of study participants were self-identifiers who responded to the researcher’s request for participation. These participants are characterized by a common identity and possibly represent common sources of underlying knowledge; this may have unintentionally skewed the findings of this study towards specific directions. Although the study revealed the presence of a few outliers, it is possible that a broader inclusion of study participants may be
more useful for establishing credibility. Future studies focused on this topic should utilize a larger sample size solicited from varied affiliations, and then, make efforts to solicit participants for interviews and focus groups through random selection and random assignment.

3. Inclusion of Multimedia

This study was not able to incorporate multimedia in the data collection processes primarily because of restrictions placed by the site director and the reluctance of a few participants. Future studies should move beyond the conventional approaches used for this study. For example, utilization of video recordings during focus groups could provide corroborating evidence for participants’ perspectives by drawing on their body language and linguistic emphases. In addition to providing an additional source of data, focus groups were instrumental for encouraging parents to share ideas, suggestions, and resources of impact for their children with other parents. At least three conversations extended well beyond the confines of focus groups; the parents continued exchanging ideas among themselves or with the researcher for several weeks after the culmination of the individual focus group sessions. Therefore, it is highly possible that one or two moderated online forums may generate powerful sources of qualitative data.
Closing

The final chapter of this dissertation summarizes the major conclusions of this study and outlines its conceptual implications. The recurring themes emerging from within the parents' efforts and decisions, and reflections and attributions form the critical bases of this dissertation. The distribution patterns and transitions may be indicative of how fathers and mothers view their involvement in children's education at various time periods and through differential resources and opportunities. It is noteworthy that whether these interventions are implemented out of parents' self-knowledge or in emulation of others' actions, a consistent sense of unrelenting persistence can be discerned throughout parents' attributions. This chapter has also identified recommendations for future research. From a methodological aspect, future studies should represent increased diversity of perspectives from multiple stakeholders engaged in STEM education, widen the demography of the research sample, and use alternative tools to gather data. Conceptually, future studies should assess the role of schools towards identifying how parents can be provided with the requisite tools and information to support their children, and the venues through which schools and parents can coordinate efforts. The above ideas will hopefully provide guidelines for emergent inquiries of this study and lead towards a steady expansion of the STEM pipeline.
APPENDICES

Appendix A: Survey for Parents

This survey has two sections. Section 1 collects information regarding the student. Section 2 collects information about how you support the student in pursuing science, technology, engineering, and mathematics (STEM).

Section 1

A. What is the grade level of your child?

B. What is the gender of your child?

C. On a scale from 1-5, where “1” is the lowest and “5” is the highest, to what extent do you think your child is interested in science, technology, engineering, and mathematics (STEM)?

   1 (lowest)  2  3  4  5 (highest)

D. Please describe how you know that your child is interested in science, technology, engineering and mathematics (STEM)?

E. What are other activities related to STEM that your child participates in besides [ASE] Program? Please Describe.

   At School:

   Out of School:

F. Has your child indicated what s/he is planning to do after finishing high school? Please describe.
Section 2

1. To be included in the [ASE] program, students have to demonstrate interest in science, technology, engineering and mathematics (STEM). What are your feelings about your child’s participation in the [ASE] program?

2. In what ways does the [ASE] Program fit within your child’s interests in STEM? What do you like about the program in terms of its benefits for your child?

3. In your opinion, what characteristics of the [ASE] program are appealing to your child?

4. In what different ways do you support your child to pursue STEM related opportunities? Please check all that apply.
   - Physical Resources (e.g. books, magazine subscriptions)
   - Advice (about course selections etc.)
   - Transportation to and from after school opportunities
   - Enrollment in after school opportunities
   - Interactions with School Personnel
   - Enrollment in summer activities
   - Participation in family conversations
   - Is there anything that I have not included (please give provide details)

5. On a scale from 1 to 5, with “1” being the lowest, and “5” being the highest, how would you rate the importance of the following:

   1 (lowest)  2  3  4  5 (highest)
   - Physical Resources (e.g. books, magazine subscriptions)
   - Advice (about course selections etc.)
   - Transportation to and from after school opportunities
   - Interaction with school personnel
   - Enrollment in summer activities
   - Participation in family conversations
   - Is there anything that I have not included (please give provide details)
6. Please provide examples of resources through which you support your child along the following categories of importance? (name and/or describe the support below each of the categories)

- Support that has had some impact on your child
  1. ________________ 2. ________________ 3. ________________

- Support that has no impact on your child
  1. ________________ 2. ________________ 3. ________________

- Support that has provided a breakthrough or turning point for your child
  1. ________________ 2. ________________ 3. ________________

7. How did/do you get ideas for the different kinds of resources that you provide for your child?

- Family members
- Friends
- From reading newspaper or any other source of information
- From watching TV
- School newsletter
- Child
- Internet based resources

8. Are there any other ways in which you support your child to pursue STEM which have not been included in the above questions?

9. Are there any sources of support which you know might be helpful to your child? Had you been able to provide those additional resources, what in your opinion would have been the impact of the added support?

10. What do you think your child feels about the different kinds of support that you provide for her/him currently?

11. What do you think about your child pursuing educational and career opportunities in STEM? On a scale from 1 to 5, with “1” being the lowest, and “5” being the highest, how would you rate the importance of your child’s participation in STEM fields?

    1 (lowest)  2  3  4  5 (highest)
Appendix B: Survey for Students

A. What is your gender? ________________________

B. What is your grade level? ________________________

C. Which description best describes you? Please fill in one box only.
   - □ American-Indian or Native Alaskan
   - □ Asian or Pacific Islander
   - □ Black, non-Hispanic
   - □ Hispanic
   - □ White, non-Hispanic
   - □ If other, please specify ________________________

1. What subjects do you enjoy the most in high school?

2. What subjects do you enjoy the least in high school?

3. Besides [ASE], what other activities do you participate in?
   At School:
   Out of School:

4. What do you like about participating in [ASE]? Has participation in [ASE] influenced your opinions about educational and career opportunities in STEM fields? Please describe.

5. Many choices are available to you after graduating from high school? Have you thought about what do you intend doing after graduation? Please describe.
6. On a scale from 1-5, where “1” is the lowest and “5” is the highest, to what extent are you interested in pursuing opportunities in science, technology, engineering, and mathematics (STEM) after you graduate from high school?

1 (lowest) 2 3 4 5 (highest)

7. Have you thought about your career choices? What are the different choices that you are interested in? How did you make decisions about any particular pathway(s) that you would like to pursue?

8. On a scale from 1-5, where “1” is the lowest and “5” is the highest, to what extent are you interested in pursuing career opportunities in science, technology, engineering, and mathematics (STEM)?

1 (lowest) 2 3 4 5 (highest)

9. From whom do you seek information to learn more about your educational and career choices? Please fill in all boxes that apply. Next to each category, please rank the following on a scale from 1 to 5, with “1” as least important and “5” as most important.

Rank from 1 and 5

Parents and family members

Peers

School Personnel

Teachers

Guidance Counselors

Administrators

Media

Television

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10. How do your parents support your participation in STEM fields? What are the different ways through which your parents support you to participate in STEM related opportunities?

At School:

Out of School:

11. In what ways are the different kinds of support provided by your parents helpful for you?

12. In what other ways would you have liked to see support from your parents? How would have the additional means of support helped you to participate in STEM opportunities?
Appendix C: Interview Protocol for Parents

Duration: 60 minutes

Currently, a great deal of attention is being paid to the opportunities available for young people in the fields of science, technology, engineering, and mathematics (STEM). Before enrolling in the [ASE] program, your child had indicated an interest in STEM related fields. You have already responded to a number of questions in the survey administered to all the consenting parents. This interview seeks in-depth understanding about how you support your child to pursue STEM related opportunities.

1. Why do you think parents should encourage their children to pursue opportunities in science, technology, engineering, and mathematics?

2. In what ways do you support your child in pursuing science, technology, engineering, and mathematics?
   (Probe: ask for examples, frequency, sources, location)

3. In your opinion, how does your child respond to the support that you extend for your child towards pursuing STEM opportunities?
   (Probe: how can you tell? Has your child said anything about the help you provide? How is your support beneficial for the child?)

4. What are your earliest recollections of interacting with your child regarding learning mathematically or scientifically oriented activities?

5. Is there something unusual or noteworthy that you are doing to support your child that you would like to share?
   (Probe: From where did you get the idea? In your opinion, what has been the added value of this particular idea?)

6. Have you had any conversations with your child about the various ways in which you support your child to pursue STEM opportunities?
Appendix D: Interview Protocol for Students

Duration: 60 minutes

Currently, a great deal of attention is being paid to the opportunities available for young people in the fields of science, technology, engineering, and mathematics (STEM). Before enrolling in the [ASE] program, you had indicated an interest in pursuing STEM related fields. You have already responded to a number of questions in the student survey. This interview seeks in-depth understanding of your opinions about the different ways through which your parents support you to pursue STEM related opportunities.

1. In what ways do your parents support you to pursue science, technology, engineering, and mathematics related opportunities? (Probe: ask for examples, frequency, sources)

2. What do you feel about the different ways in which your parents support you to pursue science, technology, engineering, and mathematics? (Probe: what do you like? Is there anything that you wish was different?)

3. Do you have information about how your friends' parents provide support for them to pursue science, technology, engineering, and mathematics related opportunities? Please describe. (Probe: What do you like about the ways in which your friends are supported by their parents? How is it different or similar to what your parents do?)

4. Is there something unusual or noteworthy in the ways that your parents support you to pursue science, technology, engineering, and mathematics? (Probe: In your opinion, what has been the added value of this particular idea?)

5. Have you had any conversations with your parents about the various ways in which they can support you to pursue STEM opportunities? What you would like? (Probe: have those conversations made any changes?)

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Appendix E: Focus Group Discussion for Parents

Questions/Prompts

1. Everyone introduce by stating:
   - Name
   - Gender of Child
   - Grade level of Child

2. All of you were invited to participate in this focus group because during the surveys and interviews used in this study, you indicated that you support your child in pursuing science, technology, engineering, and mathematics (STEM) by providing specific kinds of resources [name type of resource]. If possible you were requested to bring one or two examples/documentation of the resources that you provide for your child. This focus group will provide an opportunity for us to collectively examine and discuss these resources. To start, I would like everyone to take turns and share the resource/documentation that you have brought to the group meeting, and then, describe what you have brought to the meeting by using the following guidelines:
   - Please share a general description of the resource.
   - How did you decide to use this resource for your child? (Probe: Were you aware of any effective outcomes of this resource? How often have you used this resource previously? Has your child shared any feedback regarding this resource?)
   - In your opinion, what is the importance of this resource to your child? (Probe: In what ways does this help your child in h/her/is activities and/or at school? What does using this resource achieve within your overall efforts to support your child in pursuing STEM? For general academic goals?)

3. After each person has shared the resource they have brought to our group meeting, I would like everyone to discuss what they think about the resource?
   - Will your child find this specific resource useful? (Probe: what makes you think so? Have you used something similar to the shared resource before?)
What was your reaction then? How might you use a resource of this kind given another opportunity?)

- Have you provided something similar to help your child? What was the impact?

- Would you be willing to try ideas shared by other parents (Probe: For what purpose?)
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