

CREATING A PATHWAY TO STEM: ROLE OF AN INFORMAL MATHEMATICS  
PROGRAM

by

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A dissertation submitted to the Graduate Council of  
Texas State University in partial fulfillment  
of the requirements for the degree of  
Doctor of Philosophy  
with a Major in Mathematics Education  
August 2016

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## **DEDICATION**

This dissertation is dedicated to my parents, Renu and Pradhumna Kant. Thank you for teaching me the value of education from an early age and for respecting and supporting all my decisions. I love you both!

## **ACKNOWLEDGEMENTS**

First, I am very thankful to the participants in my study. Thank you so much for sharing your diverse experiences! Without your help this project would not have been possible. I am deeply grateful to my advisors, Dr. Max Warshauer and Dr. Alex White, for their support and encouragement all these years. Thank you both for believing in me, pushing me, having high expectations from me, and supporting me in every way! Max, you have been an exceptional teacher, mentor, and advocate for me! You continually encouraged me to publish articles, present at conferences, and to set my sights high. I cannot thank you enough for all the opportunities you provided me throughout these past years! Max, from you I have learned how to think creatively, take risks, and be passionate about my work as you model these qualities everyday. It is rare to find a mentor like you and I am honored to have you as my advisor. I truly value and treasure the parent like concern you have shown for my progress all these years! Dr. White, you are an amazing and a very genuine person! I have come to value you as an excellent teacher, mentor, researcher, and a treasured friend. You made the daunting process of writing a dissertation not only doable but also enjoyable! The numerous conversations I had with you about issues of gender, race, and class in math education gave me much food for thought. I would look forward to our weekly meetings with much anticipation to work on my dissertation and to our stimulating discussions about world issues. I cannot thank you enough for always checking up on my progress and being there for me whenever I needed help! Your self-less commitment to your students and your work ethic is truly

inspiring; my respect for you continues to grow everyday! I am honored to have you as my advisor. I am also thankful to my committee member Dr. Hiroko Warshauer who took personal care to go through my entire dissertation and provided thoughtful feedback. As my committee member Hiroko was instrumental. She would send me numerous articles, lend me pertinent books, and would take the time to chat with me about my research interests. Hiroko you are an extraordinary mentor! To my committee member – Dr. Samuel Obara, thank you for all your encouragement and support! You provided unique and insightful perspective on the feedback that made my dissertation all the more better. I have learned so much from you and could not have come this far without your help! To my committee member Dr. Na'ilah Nasir, thank you for inspiring me to conduct my research in an equity area! Your work was instrumental in completing my dissertation and it continues to be an inspiration. Thanks so much for providing valuable feedback! To Dr. Anna Sfard, thank you for serving on my committee during the proposal development stage of my dissertation! Your detailed feedback on my proposal and your help with crafting excellent interview questions was invaluable! Thanks to my entire committee! All of you have impacted my personal and professional development in numerous ways and I am grateful to each of you!

To my first professor at Texas State – Dr. Terry McCabe, thank you for being such an amazing teacher! Terry, from you I have learned what it means to be a great educator. You are such a talented professor and yet you are so humble. I really admire you as a person. To all my professors – Dr. Passty, Dr. Acosta, Dr. Welsh, Dr. Sorto, Dr.

Strickland, and others and to all the math office and Mathworks staff, thank you for always offering kind and encouraging words whenever I ran into you all in the hallways or in the office! Thanks to all my friends – Christina Starkey, Christina Zunker, Sonalee, Sarah, and so many others for offering encouragement, sharing their experiences, and making graduate school such a rewarding and enjoyable experience! To my dearest friend Alana, thank you for being there for me every step of the way and checking up on me! Thank you for all those long lunches and conversations that provided much needed respite and renewed energy that kept me going! And thank you so much for Arkansas! You are an amazing woman Alana Rosenwasser!

To my uncle Kaveesh and my cousin Mayank, thank you for all your support and encouragement in helping me pursue my education. I have always looked up to both of you as examples of people who are so successful and yet very humble. Without your kindness and generosity this endeavor would not have been possible. I really appreciate all your help! To my best friend Raed, thank you for asking me all the tough questions and keeping me honest. From you I learned the importance of having a sense of justice present in all my dealings no matter how ordinary. Our numerous conversations have helped me strengthen my sense of justice that I learned growing up from my family. Raed, from you I learned what it truly means to walk a mile in someone else's shoes and how important this perspective is in understanding others' experiences. I will always treasure our friendship as it keeps me grounded and encourages me to become a better person everyday.

To my parents who taught me the importance of education from an early age and who made numerous sacrifices to help me throughout my educational journey. Thank you for being available to talk to me no matter what time of day or night and letting me vent, encouraging me to persist, and offering me sound advice. Your love and support is a source of strength that helps me face new challenges with courage and grace.

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## DEFINITION OF TERMS

The definition of the key terms and phrases used in this dissertation is provided below:

**STEM:** An acronym that stands for Science, Technology, Engineering, and Mathematics.

In the context of this study, higher education and/or career in a STEM area would mean earning a degree in and/or working in the following or related fields - mathematics, applied mathematics, statistics, natural sciences (physics, chemistry, and biology), medicine, computer science & information technology, engineering in sciences and/or technology.

**Socio-Economic Status (SES)/background:** The social standing or class of an individual or group. It is often measured as a combination of education, income and occupation. Examinations of socioeconomic status often reveal inequities in access to resources, plus issues related to privilege, power and control (“Education and Socioeconomic Status,” 2016).

**Minority:** In the context of this study we will take minority to mean a group that experiences a narrowing of opportunities (success, education, wealth) that is disproportionately low compared to their numbers in the society (Schaefer, 1993). Note that I will use the terms traditionally underrepresented women or underrepresented women to mean women from low SES and/or ethnic minority backgrounds.

**Mathematical competence:** to engage in sense-making and problem solving using and developing mathematical representations, concepts, and methods as resources (Boaler &

Greeno, 2000, p. 172). In the context of this study, the term *mathematical competence* will be used interchangeably with the notion of knowing, understanding, and creatively using mathematics.

**Informal math programs/camps:** extracurricular math programs such as after school math clubs, enrichment programs, summer camps that focus on educational activities that are not part of standard school curricula and whose purpose is to provide unique learning spaces in which students' interest and talent in mathematics can be further developed.

**Educational and Career aspirations:** In the context of this study educational and career aspirations would mean one's hopes and desires for one's education and occupation in the future.

**Mathematics Learning Identity (first-person identity):** collection of stories – reifying, endorsable, and significant (Sfard and Prusak, 2005) and all that which involves particular beliefs about - the nature of mathematics, learning and epistemologies of mathematics, self as learners of mathematics (a perception of oneself as a potential creator of, or participant in, mathematics), and larger societal discourses on gender, ethnicity, or class (Solomon, 2009).

**Practice-linked identities:** the relationship between learning and identity in the context of a practice may be defined as follows - learning is considered to be shifts in use of artifacts (both cultural and cognitive) for problem solving, sense making, or performance. Identity is considered to be one viewing participation in the practice as an integral part of who one is (Nasir and Hand 2005, 2008 as cited in Nasir & Cooks, 2009)

**Inbound practice-linked identity trajectory:** newcomers joining the community with the prospect of becoming full participants in its practice (Wenger, 1998 as cited in Nasir & Cooks, 2009; Solomon, 2009).

**Marginalized identity trajectory:** learner loses the sense of belonging in a practice due to various reasons such as non-participation, lack of access to opportunities to learn, lack of ownership during participation, alignment to a narrow view of learning (Solomon, 2009).

**Social Capital:** Resources accessed in social networks that depend upon human capital (self/parental education and experiences), initial positions (parental or prior occupational statuses) and one's social ties (e.g. kin, friends, acquaintances, colleagues, organizations). Social capital enhances the chances of attaining better statuses/socioeconomic standing (Lin, 1999).

## **ABSTRACT**

This dissertation presents the findings of a single-site, qualitative, embedded case study involving four former (1990 – 2008) participants of an informal math program in US. The purpose of this study is to describe in my words the stories of the participants from economically disadvantaged and/or minority backgrounds who attended a university affiliated informal mathematics summer program – Riverside Summer Math Camp (RSMC) during their high school years, about (a) how this program affected their mathematics learning identity (MLI), (b) how this program impacted their social capital (SC) and influenced their educational and career trajectories, (c) what particular characteristics of this program do they value. The retrospective aspect of the study allows for looking at the long-term effect of a math camp on the educational and career trajectories of the participants in order to gain a better understanding of the role that informal math summer camps such as RSMC play in increasing the participation of women in STEM, if any. The research questions were answered based on the data obtained from participants' past data sources (journals, camp evaluations, and essays from during the time they attended RSMC) and their present data sources (interviews, preliminary survey, and recent correspondence). The ecological perspective provides a theoretical framing of the study and was operationalized using Nasir and Cooks' (2009) identity resource model in order to analyze the data. Four individual case reports as well as cross-case analysis are presented. The findings of the study indicate that

(1) All four participants displayed a narrow and ritualized pre-MLI in a procedure driven

figured world of their respective school environments. Upon attending RSMC, all four participants developed a broad and holistic understanding of the field of mathematics, learning, and themselves as learners of math. Three of the participants were also able to confront previously held stereotypical views about race, gender, national origin, and/or class in the context of learning math.

(2) All four participants reported varying degrees of limited social capital prior to coming to RSMC. This limited social capital included financial constraints, lack of female role models, and lack of family support. The data suggests that RSMC had a crucial impact on the participants' higher education/career trajectory and the decisions they made regarding applying to some of the top-ranked institutions of higher learning by increasing their SC. There were additional findings that came to light about the college experiences of two of the four participants, which are also discussed.

(3) Some of the common practices/components valued by all four participants in the past and in the present that led to the impact on their respective MLI and SC include - study groups, mentorship received from the camp director, teaching practices at camp, a sense of community, the help and mentoring received from the counselors, social aspects (e.g. weekend trips), and the camp curriculum.

I have also included: (i) a discussion of the key findings situated within the context of the existing literature (e.g. Boaler & Greeno, 2000; Nasir & Hand, 2008; Solomon, 2009; Nasir & Cooks, 2009; Nasir et al., 2012; McGee, 2015) (ii) pedagogical implications for math educators to promote equitable teaching and learning in various

settings, and policy makers for supporting and funding efforts of university affiliated math camps (iii) a framework for establishing an equity based education model (aiding in the construction of positive, holistic, and broadened learning identities) that applies to informal math programs or can be extended to other learning settings, and (iv) recommendations for future research.

## **I. INTRODUCTION**

### **A case for STEM education and women's participation**

President Obama launched his campaign to support and increase the participation of women as well as other traditionally underrepresented groups in Science Technology Engineering & Mathematics (STEM) fields (The White House, 2013). The Office of Science and Technology Policy at the White House released the following statement from the President “One of the things that I really strongly believe in is that we need to have more girls interested in math, science, and engineering. We’ve got half the population that is way underrepresented in those fields and that means that we’ve got a whole bunch of talent...not being encouraged the way they need to.” (President Barack Obama, February 2013). The President also noted that supporting women in STEM is not only critical to ensure America’s global leadership but it is “an important step towards realizing greater economic success and equality for women across the board” (The White House, 2013). Under ‘Race-to-the-Top’ education initiative, the President put state-level innovation at the center stage inviting the states’ best ideas to prepare all students for college and careers in demanding areas such as STEM (The White House, 2014).

### **Underrepresentation of women in STEM areas**

It has been documented in the literature (e.g. Barton et al., 2013; Jacquot, 2009; Fadigan & Hammrich, 2004; National Science Foundation, 2000) that STEM related fields have had a long history of underrepresentation of women. Despite the government’s push for strengthening STEM related education and careers, women (especially from minority and low socio-economic backgrounds) continue to remain concentrated in traditionally female dominated fields (National Center for Education

Statistics [NCES], 2000). In 2010, ‘secretaries and administrative assistants’ ranked number one in the 20 most prevalent occupations for employed women in the U.S. (Women’s Bureau, 2010). Flora Lichtman of National Public Radio (NPR) recently reported a story titled ‘The STEM Gender Gap’ in the Science Friday show. Lichtman reported that even though the number of girls and women completing at least a high school diploma has risen in the recent years, there still exists a gender gap in higher education and the work force especially in STEM areas. Lichtman goes on to report in her show that among college graduates males continue to outnumber females “in nearly every science and engineering major, according to a report by the American Association of University Women. Furthermore, women make up less than a quarter of all the STEM workforce in the U.S., according to the U.S. Department of Commerce.” This gap is only widened when race, ethnicity, and socio-economic status are taken into account along with gender (e.g. Sanders et al., 1997; Women's Bureau, 1997; Lim, 2008; Robinson & Lubinski, 2011; Pinar, 2011). In 2010 among female race/ethnic groups unemployment rate of 12.3% was reported among Hispanic women and 13.8 % among black women (Women’s Bureau, 2010). Several studies (e.g. Fadigan & Hammrich, 2004; Jacquot, 2009; Barton et al., 2013) argue citing pertinent statistics that despite the progress that has been made in the degree of representation of women in STEM areas, when representation in individual STEM categories are examined there seem to be an inequity in areas such as mathematics, statistics, computer science, physics, and engineering. For example, according to the data from National Science Foundation (NSF) in Science and Engineering indicators – 2000, “women constituted 63% of psychologists and 55% of

sociologists, but only 10% of physicists and 9% of engineers” (Fadigan & Hammrich, 2004, p. 836; NSF, 2000).

### **Factors influencing women’s educational and career choices**

The factors affecting women’s educational and career choices with respect to STEM related fields are complex and often interrelated (Barton et al., 2013; Jacquot, 2009; Lim, 2008; Pinar, 2011; Fadigan & Hammrich, 2004). Some of these factors include cognitive ability, experiences in math and science classes, socialization, parental support, race, ethnicity, socio-economic status, social capital, learning identity, interest and aspirations, gender roles, among others that have been documented in the literature (e.g. Barton et al., 2013; Fadigan & Hammrich, 2004; McCarthy & Moje, 2002; Boaler & Greeno, 2000; Eccles, 1994). In this study I shall focus on two of these factors – Mathematics Learning Identity (MLI), and Social Capital (SC). I shall describe these factors and some of the literature that exists in exploring them in the context of informal educational programs such as math and science camps in chapter 2.

Studies show that only a small percentage of women who aspire to a STEM related higher education and careers end up achieving their goals (Fadigan & Hammrich, 2004). Therefore, research needs to continue in identifying avenues in society and explore the role such avenues play in aiding and facilitating the factors which impact girls’ and women’s aspirations to pursue a STEM related higher education and/or career (Barton et al., 2013; Morrow & Schowengerdt, 2008; Fadigan & Hammrich, 2004; Darke et al., 2002) so that young women who aspire to become mathematicians and scientists are able to materialize their aspirations.

## **Mathematics is at the root of future STEM involvement**

In the present day society, proficiency in mathematics is a necessary condition to be considered college ready. Various college entrance exams such as PSAT, SAT, ACT, NMSQT have a required math component. Proficiency in mathematics is considered even more important if the student is planning to major in areas such as medicine, technology, engineering, physics and other natural sciences. “The math pathway for students pursuing majors in the math-oriented disciplines is well established: Students work their way through algebra to calculus. Certainly, students entering science, technology, engineering, and mathematics fields need to be proficient in pre-calculus and the algebra on which it depends...” (Bryk & Treisman, 2010). In 1989 the National Council of Teachers of Mathematics (NCTM) published the following statements in their curriculum and evaluation standards for school mathematics describing the education goals that better address the society’s needs in the information age

Mathematics has become a critical filter for employment and full participation in our society. We cannot afford to have the majority of our population mathematically illiterate: Equity has become an economic necessity. (p.4, NCTM standards, 1989 as cited in Stinson, 2004).

Similar to NCTM’s position on the role of mathematics in society, other mathematics educators and scholars (e.g. Frankenstein, 1995; Stinson, 2004; Bryk & Treisman, 2010) have argued and provided statistical evidence on the importance of mathematics as a gatekeeper or a gateway in providing access to higher education in academia and better employment opportunities in the job industry. For example, Stinson (2004) cites reports from U.S. Department of Education which base their

recommendations on evidence such as 71% of the low-income students who took algebra I and geometry went to college, occupations requiring a bachelor's degree or higher will average 23 percent growth, almost double the 12 percent growth rate projected for occupations that require less education and training [in math or science] by year 2005 etc. Furthermore, some mathematics educators (e.g. Skovsmpse & Valero, 2008; Anderson & Tate 2008) consider mathematics literacy integral to functioning in a democratic society. For example, Malloy (2002) as cited in Anderson & Tate, 2008 describes the concept of democratic access as “providing students with the opportunity to see that mathematics is connected to the social needs of the community and that mathematics can expand and deepen the democratic possibilities for equity...”(p.301).

Thus, there is an abundance of evidence in the literature (e.g. NCTM, 1989; Stinson, 2004; Skovsmpse & Valero, 2008; Anderson & Tate 2008; Bryk & Treisman, 2010) that puts mathematics not only at the root of STEM involvement but also recognizes it as integral tool to ensure active and critical public participation in a diverse and democratic society.

### **Informal Mathematics Programs and STEM involvement**

Efforts are being made to increase girls' and women's participation in STEM and narrow the gender gap through various after school programs, informal math and science programs such as university affiliated summer camps, and mentoring programs (Fadigan & Hammrich, 2004; Morrow & Schowengerdt, 2008). There have been some studies (Barton et al., 2013; Darke et al., 2002; Fadigan & Hammrich, 2004) that have identified math and science summer camps, after school math or science clubs, and mentoring programs as having a positive effect on girls' self-concept and learning identity with

respect to STEM related fields. However, more research is needed - (a) in understanding the role such programs play in influencing the learning identity as well as some of the other factors that research has identified such as mathematics competence and social capital among others that may impact women's aspirations to pursue a STEM related higher education and/or career; and (b) to gain a better understanding of the characteristics and long-term effects of such programs on the educational and career choices made by young women from minority and low socio-economic backgrounds. I will use the phrases traditionally underrepresented or underrepresented to mean individuals from minority and/or low socio-economic backgrounds.

### **The Program of Study – A brief introduction**

In this chapter I shall briefly introduce the program of study. I shall elaborate more on its vision for learning and particular structure and practices over the years in chapters 2 and 3 respectively. The information provided in this introduction comes from the program website and from an interview with the program director.

Riverside Summer Math Camp (RSMC) is an intensive multi-summer program for high school students who are excited about doing mathematics. The goal of the program is to develop talented youth of all backgrounds by an immersive and in-depth experience in a unique learning environment. Students develop important skills for future degrees and careers in math, science, engineering, and many other fields. Students are taught by university faculty and mentored by undergraduate counselors. These counselors are former math campers who return to RSMC during the summer to mentor a new generation of campers. It is a goal of RSMC to provide an intellectually nurturing environment for all students. Some of the courses taught at RSMC include Number

Theory, Analysis, Combinatorics, Research Topics, and Honors Seminar. In addition students are provided opportunities to conduct original research under the guidance of a faculty member. Rising 9th – 12th graders are eligible to apply to the first year program. A maximum of 32 first-year (first time) students are accepted. The typical ratio of boys to girls in the program is 1:1. RSMC also offers camp scholarships based on financial need and every effort is made to ensure students can attend regardless of their financial background. This is a residential camp so students live in a campus dormitory at a University under the supervision of the counselors. Besides exploring and enjoying mathematics with their peers, students also enjoy other social activities such as picnics, hiking, theater etc.

### **Problem Statement**

The fact that a gender gap still persists and there continues to exist under-representation of women (especially women from minority groups and low SES) in STEM areas is a significant problem in a society that espouses and celebrates the American dream. Although, efforts are being made to increase girls' and women's participation in STEM and narrow the gender gap through various after school programs, university affiliated summer camps, and mentoring programs (Fadigan & Hammrich, 2004; Frost & Wiest, 2007; Morrow & Schowengerdt, 2008), more research is needed to understand the extent to which such programs are effective in shaping the educational and career related decisions of young women.

There exists a gap in the literature regarding how informal educational programs in general and math summer camps in particular may influence factors, such as mathematics learning identity, and social capital, affecting women's educational and

career trajectories with respect to STEM related fields. Furthermore, there has not been much research on classifying the characteristics of such camps and determining the role of such avenues on impacting the educational and career choices of young women from minority and/or low SES backgrounds (Morrow & Schowengerdt, 2008; Fadigan & Hammrich, 2004). This in itself is a crucial part of the problem. Therefore, I argue that there is a need for this study to (a) better understand the aforementioned issues from the perspective of the participants and (b) establish a model for investigating the role of alternative learning settings in promoting equitable teaching and learning for all students and in particular underrepresented young women aspiring to enter STEM higher education and careers.

### **Purpose of the Study and Research Questions**

The purpose of this study is to describe in my words the stories of the participants from economically disadvantaged and/or minority backgrounds who attended a university affiliated informal mathematics summer camp program – RSMC during their high school years, about (a) how this program affected their mathematics learning identity, (b) how this program impacted their social capital and influenced their educational and career trajectories, (c) what particular characteristics of this program do they value.

The retrospective aspect of the study allows for looking at the long-term effect of a math camp on the educational and career choices made by traditionally underrepresented young women in order to gain a better understanding of the role that informal math summer camps such as RSMC play in increasing the participation of women in STEM related fields, if any.

Furthermore, the narrative aspect of the study using participants' stories (through interviews, written journals in the past, and other documents) as data to study the impact of the camp as envisioned by the participants, presents a different facet of reality when compared to using observational data to study the same topic. Though different from describing the impact of the camp based on my observations of the participants, describing and relating in my words the participants' stories about reality is in some respects even more significant. These stories are important and worth telling because they constitute one's reality. They are our history and they can shape our future by impacting our actions. Since the beginning of civilization, human beings have always attempted to describe their experiences in the form of storytelling whether through writing their accounts or orally narrating them. We make sense of our world, our experiences and non-experiences by constructing narratives. Sikes and Gale (2006) describe the importance of narratives in research as "The narrative structures and the vocabularies that we use when we craft and tell our tales of our perceptions and experiences are also, in themselves, significant, providing information about our social and cultural positioning: to paraphrase Wittgenstein (1953), the limits of my language are the limits of my world." Similarly, when describing the importance of narratives to study the construct of identity in educational research Sfard and Prusak (2005) state "Narratives that constitute one's identity, being an important factor in shaping this person's actions, will be useful in research even if they communicate one's experiences only as well as human words can tell..." (p. 17).

The primary audience for my research findings would include informal mathematics program practitioners, policy makers for supporting and funding efforts of

university affiliated math camps from federal, state, local, and private sources, funding agencies such as National Science Foundation and private sources such as the Gates foundation that are looking for avenues to help increase the participation of women in STEM fields, and other researchers.

My research questions for this study are:

1. How do the women participants (1990 – 2008, from low SES and/or minority background) of an informal, university affiliated, summer math camp –RSMC envision its influence on their *mathematics learning identity*?
  - a. According to the participants, what was the nature of their *mathematics learning identity* (1<sup>st</sup> P) at the time they started the program?
  - b. What views did these participants hold in the past (as recorded in their past documents such as journals) and what views do these participants hold at present (as narrated in their recent interviews, correspondence, survey) about the influence of RSMC (i.e. its particular affordances) on development of their *mathematics learning identity*?
2. How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their higher education and/or career trajectory in STEM areas?
3. Which particular characteristics/practices of the RSMC program did these participants come to value, if any, that led to the above impact?

The research questions stated above were studied using an embedded case study methodology and follow a retrospective design. These questions were answered based on

the data obtained from participants' past and present data sources. Participants' past data sources included documents such as journals, camp evaluations, and essays from during the time they attended RSMC. Their present data sources included interviews, preliminary survey, and recent correspondence.

### **Delimitations**

This study focuses on four female participants from low SES and/or minority backgrounds who attended one summer math camp – RSMC.

### **Significance of the Study**

This study extends the existing but limited body of research on how math summer camps may influence factors affecting women's educational and career trajectories with respect to STEM related fields such as their mathematical learning identity and social capital thereby contributing to the literature in better understanding the role of university affiliated summer math camps play in increasing STEM participation of young women. In addition, this study seeks to inform the practices of such math camps by identifying the characteristics that help or hinder the experience of traditionally underrepresented women participants. This helps in establishing a model for better understanding learning settings. For example, how learning environments of informal programs may help support (or not) the education and career trajectories of young women from diverse backgrounds. Finally, this research has policy implications for supporting and funding efforts of university affiliated math camps from federal, state, local, and private sources.

### **Summary**

As mentioned earlier there is a growing need for STEM professionals in U.S. and a push from public and private sectors to increase the research and innovation capacity of

the nation. However, there still exists under-representation of women (especially women from minority groups and low SES) in STEM areas. Federal agencies such as the Office of Science and Technology Policy, National Science Foundation and private sources such as the Gates foundation are looking for avenues to help increase the participation of women in STEM fields. There has been some evidence (e.g. Barton et al., 2013; Morrow & Schowengerdt, 2008; Frost & Wiest, 2007; Fadigan & Hammrich, 2004; Darke et al., 2002) that positively correlates the effect of avenues such as informal math and science programs on higher educational and career aspirations of traditionally marginalized students such as girls and minorities in STEM areas. Research (e.g. NCTM, 1989; Frankenstein, 1995; Stinson, 2004; Bryk & Treisman, 2010) has shown that Math plays a vital role as a gatekeeper for entry into Science, Technology, and Engineering higher education and careers. Because there is a gap in the literature regarding the role that university affiliated math camps play in influencing factors, such mathematics learning identity and social capital, and how they affect women's educational and career decisions with respect to STEM related fields and because there is not enough research to identify what particular characteristics of such camps impact the aspirations and eventually educational and career trajectories of women from minority and/or low SES backgrounds, therefore, I argue that there is a need for this study to explore in depth the aforementioned issues from the perspective of this population by studying the participants from one such camp and narrating their stories.

In the next four chapters I will extend the review of the literature surrounding the research questions for my study and present my theoretical framework, describe my research methodology, present my findings as individual case reports of the participants

followed by a cross-case analysis, and discuss the findings as they relate or extend the pertinent literature as well as discuss the implications of the findings.

## II. LITERATURE REVIEW

In this chapter I extend the review of the literature from Chapter I, discuss the pertinent gap in the literature, and present my theoretical framework for the study. This chapter is divided into the following sections:

- (1) Focusing on two factors influencing women's educational and career trajectories  
– mathematics learning identity and social capital;
- (2) Informal Mathematics Programs
- (3) Gap in the Literature
- (4) Theoretical Framework

### **Factors influencing women's educational and career trajectories**

In this research, I am interested in studying the role that an informal, out-of-school, university affiliated, summer math camp (Riverside Summer Math Camp [RSMC]) plays, from the perspective of its participants, in influencing two aspects grounded in the literature –mathematical learning identity and social capital that affect the STEM related education and career aspirations of girls. I decided to focus on the aforementioned factors in my study because even though literature (e.g. Eagan et al., 2013; Barton et al., 2013; Eccles, 2011; Morrow & Schowengerdt, 2008; Fadigan & Hammrich, 2004; Darke et al., 2002) exists that links students' mathematical competence and learning identity, and/or social capital to their aspirations in pursuing STEM related education and careers, there is a gap in the literature with respect to exploring the interaction of these constructs in the context of math camps and its female participants. In addition, I am interested in identifying the characteristics of RSMC as reported by its

participants that influenced their decision to pursue STEM related activities. Below I extend on the literature that describes the above-mentioned factors:

### **Mathematics Learning Identity**

A myriad of domestic and international literature (e.g. Boaler & Greeno, 2000; Sfard & Prusak, 2005; Barton et al., 2013) exists on learning identities or mathematics identities among female students and is identified as a major factor influencing young women's decisions about pursuing a math or science related education. The concept of identity is quite complex and has been extensively explored in the past decade in several studies (e.g. Boaler & Greeno, 2000; Boaler, 2002; McCarthy & Moje, 2002; Sfard & Prusak, 2005; Martin, 2006; Nasir & Cooks, 2009; Solomon, 2009; Nasir et al., 2013). Several definitions of identity and in particular mathematics identity are found in the literature. Here I provide some of the common definitions from the literature of the construct of identity, learning identity, or mathematics identity. Unfortunately, they share a common associated problem – they are difficult to operationalize. For example some researchers (Holland et. al, 1998 as cited in Boaler & Greeno, 2000) have looked at the construct of identity in terms of how one comes to understand and enact his or her position in the “worlds” he or she lives and participates. In this way, a person could be living in multiple figured worlds such as academia, romance, marriage, or a political group and depending on the practices of that figured world will exhibit different identities. Furthermore, Holland et al. (1998) as cited in Boaler and Greeno (2000) define figured worlds as “places where agents come together to construct joint meanings and activities ... Figured worlds are socially and culturally constructed realms...where people take on certain roles that help define who they are” (p. 173). Researchers such as Jo

Boaler (2000, 2002a) build on the ideas of Holland et al. (1998) and view learning as the process of identity formation in figured worlds. Identities are seen as relationships that emerge when the learner interacts with the discipline of mathematics by engaging in the classroom practices. Similar to these ideas are Wenger's (1998) conceptions of identity, which he defines as "a layering of events of participation and reification by which our experience and its social interpretation inform each other. As we encounter our effects on the world and develop our relations with others, these layers build upon each other to produce our identity as a very complex interweaving of participative experience and reificative projections...Identity is therefore cumulative: it is built over time as we participate (or not) in a community of practice, and the nature of our participation and our location of ourselves is interpreted in terms of the values, assumptions and rules of engagement and communication of the practice" (Wenger, 1998 as cited in Solomon, 2009, p. 24). However, Nasir and Cooks (2009) raise an important point about preserving the distinction between the processes of learning and identity. These authors define practice-linked identities by viewing learning as "shifts in use of artifacts (both cultural and cognitive) for problem solving, sense making, or performance" and identity as "one viewing participation in the practice as an integral part of who one is" in the context of a practice (Nasir & Cooks, 2009, p. 44). Martin (2006) defines mathematics identity as dispositions and deeply held beliefs about the ability to perform effectively in mathematical contexts and to use math to change one's life. In this way one's mathematics identities are self-understandings built within context of doing math. However, Sfard and Prusak (2005) and later Sfard and Heyd-Metzuyanim (2011) raise an important point in their paper 'Telling Identities: In search of an analytic tool' and the

talk ‘speaking of counting’, respectively, that most definitions that occur in the literature related to the construct of identity in the context of mathematics education are difficult to operationalize since the authors don’t specify how one can decide “who” or “what kind of a person” is a given individual. Sfard and Prusak (2005) view identity-making as a communicational activity and provide a more operational definition of identities as a “...collections of stories about persons ... that are reifying, endorsable, and significant” (p. 16). Note the use of the plural form – identities instead of the singular – identity when defining this construct. The authors explain that this is because multiple identities exist for a person in form of different stories depending upon who is telling the story about this person and for whom the story is intended. Sfard and Prusak (2005), Sfard and Heyd-Metzuyanim (2011), and Heyd-Metzuyanim and Sfard (2012) provide the following description of identity in the context of learning mathematics by viewing it as discursive (communicational, discourse related) practice as well as differentiate between 1st person, 2nd person, and 3rd person identities:

Identity of A equals stories about A that reify A’s actions (using the verb be or have rather than do and avoiding past tense; For example “I am good with fractions”, “She has a gift in mathematics”), are endorsed by their author (the author believes they apply to A), and are significant to their author (they have an impact on how the author feels about A i.e. any change in the narrative affects the author’s feelings about A). In this way we can speak of different identities of A depending upon who is telling the story to whom. Different identifying stories considered as narratives may be represented as a triple  ${}_B A_C$ , where B = the author, A = the identified, C = the recipient. Using the triple representation various

identities of A include -  ${}_A A_C$  (first-person or 1st P identity),  ${}_B A_A$  (second-person or 2nd P identity), and  ${}_B A_C$  (third-person or 3rd P identity). An important narrative then is  ${}_A A_A$ , which are self-told stories about oneself to oneself. This narrative usually has the most immediate impact on our actions. Another characteristic of identity in this definition is that identities are properties of actions turned into properties of the actor; they are descriptions of past events turned into prescriptions for future actions based on the assumption that despite the process of change and fluid nature of circumstances much of what we see in the present moment with respect to one's actions shall repeat itself in a similar situation in the future; therefore identities make it possible for us to interpret the present situation in terms of the past experience and provide us with tools to plan for the future.

Also relevant here is the work of Yvette Solomon (2009) entitled *Mathematical Literacy: Developing Identities of Inclusion*. Solomon (2009) incorporated multiple aspects of identities from various authors (e.g. Wenger, 1998; Gee, 2001; Edwards & Mercer, 1987; Sfard & Prusak, 2005) to study the development of learning identities among students in the UK from elementary to undergraduate years. In her book, Solomon (2009) studies the processes involved in promoting mathematical literacy which depend upon the development of identities of inclusion “and all that that involves: particular beliefs about oneself as a learner and about the nature of mathematics, an identity of engagement in mathematics and a perception of oneself as a potential creator of, or participant in, mathematics” (p. 27). She considers the idea of individual trajectories through mathematical learning as “interwoven products of many moments which add up

to our mathematical lives or identities” (p. ix). She explores this concept of mathematical lives or histories among students in terms of their engagement in a community of practice, their epistemologies of mathematics, and their discourses of gender/ethnicity/class, pedagogy, and mathematics itself (Solomon, 2009). The author therefore believes that “learners, drawing on their experiences of schooling and their wider identities of gender, ethnicity and class in turn construct corresponding mathematics identities as they negotiate the educational system and the discursive positionings which it makes available to them” (Solomon, 2009, p. 27). Solomon (2009) as well as Nasir and Cooks (2009) describe the concept of identity trajectories resulting from participation (non-participation) in a community of practice. For the purposes of this study I will consider two types of trajectories – inbound practice-linked identity trajectory and marginalized identity trajectory. Inbound practice-linked identity trajectory may be defined as newcomers joining the community with the prospect of becoming full participants in its practice (Wenger, 1998 as cited in Nasir & Cooks, 2009; Solomon, 2009). On the other hand, marginalized identity trajectory may be defined as a trajectory that excludes the learner from the practice. Learner loses the sense of belonging in a practice due to various reasons such as non-participation, lack of access to opportunities to learn, lack of ownership during participation, alignment to a narrow view of learning (Solomon, 2009).

For my research to study the construct of mathematics learning identity (MLI) in terms of first-person identity (1st P), I shall make use of Sfard and associates’ (2005, 2011, 2012) discursive (collection of stories – reifying, endorsable, and significant) definition and how Solomon (2009) defines the concept of identities (in terms of beliefs

about mathematics, learning, self as a learner, and discourses of gender/ethnicity/class) as noted above. This definition of MLI would also allow for Nasir and Cooks' (2009) recommendation for studying the relationship between learning and identity while also preserving the distinction between the two processes. I shall consider the construct of MLI in the context of Boaler and Greeno's (2000) and Boaler's (2002a, 2002b) view of development of learning identities as part of ecologies of participation in a community of practice. One crucial thing to now note is that MLI may originate in one's experiences in a learning environment and maybe shaped by the extent of one's participation in a community of practice, however, it is the narrating of how one views her relationship with the subject of mathematics and what helped (hindered) her to feel this way is all that we have as a practical tool to study MLI (especially in a retrospective study where interviews constitute a main source of data). As Sfard and Prusak (2005) aptly note, the narrative definition of identities presents them as discursive counterparts of one's experiences and narratives are certainly useful in educational research "...even if they communicate one's experiences only as well as human words can tell..." (p. 17). This way it is reasonable to study one's MLI through a collection of stories (narrating one's experiences that contributed to one's relationship with mathematics) in the context of a learning environment and one's participation in its practices. In fact, as it happens I am studying all of my research questions in terms of participants' narratives whether written or oral. Borrowing from and elaborating on Sfard and Prusak's (2005) model of representing identities as a triple, I consider the self-told stories (in the context of learning mathematics)  $A_A$  to be significantly influenced by  $A_C$ ,  $B_A$ , and  $B_C$  as well as the collection of stories about members of a larger group centered on characteristics

such as a race, ethnicity, nationality, class, or gender with which A identifies represented as  ${}_B G_A$ . However, I do not truly have access to  ${}_A A_A$ . Therefore, my access to study MLI is limited to  ${}_A A_C$  (1st P identities) and/or  ${}_B A_C$  (3rd P identities). The definition of MLI in my study has three important aspects – (i) math competence (which includes conceptions of math and learning), (ii) perceptions of self as learner of math (which includes self-confidence, viewing oneself as a potential creator of and an active participant in the field), and (iii) narratives of gender/ethnicity/class influencing one's learning and sense of belonging in the field of mathematics.

Viewing the construct of MLI as described above gives me the necessary tools to – (a) operationalize the construct as a collection of stories that are reifying, endorsable, and significant, (b) situate the process of identity construction with respect to mathematics learning in the context of the learning environment, and (c) view identities as a function of properties of our actions overtime i.e. trajectories resulting from past experiences and our participation in a community of practice that shape our future in a given figured world. Below I present pertinent literature with respect to the three aspects of MLI discussed above:

### **MLI - mathematical competence aspect**

I shall use the term mathematical competence interchangeably with the notion of knowing, understanding, and creatively using mathematics from here on. There are several definitions of mathematical competence that exist in the literature. This implies that people conceive of differently about how knowing and understanding of mathematics develops in individuals. For example, Werdelin (1958) as cited in Aiken (1973) defines mathematical competence as "...the ability to understand the nature of mathematical (and

similar) problems, symbols, methods and proofs; to learn them, to retain them in the memory, and to reproduce them; to combine them with other problems, symbols, methods, and proofs, and to use them when solving mathematical (and similar) tasks.” (p. 405). On the other hand Boaler and Greeno (2000) define knowing and understanding mathematics as “...[the ability to] engage in sense-making and problem solving using and developing mathematical representations, concepts, and methods as resources...[through participation] in the practices of mathematical discourse and thinking” (p. 172). According to this view development of mathematical knowledge or learning mathematics is tantamount to the participation in the practices of mathematical discourse and thinking (Boaler & Greeno, 2000).

Learning and doing mathematics may mean different things to different people. Hence, there are different types of mathematical abilities or ways of knowing mathematics that individuals develop based on the practices of the environments in which they engage with the discipline of mathematics. Becker (1995) summarizes the ideas presented in the book ‘Women’s Ways of Knowing: The Development of Self, Voice, and Mind’ by Belenky, Clinchy, Goldberger, and Tarule (1986) and discusses the implications of these ideas in the context of encouraging women to pursue higher education and careers related to mathematics. Similarly, Boaler and Greeno (2000) extend the ideas of Belenky et al. (1986) in their study, which explores “students’ mathematical understanding as well as the choices they make about life and work” (p. 172). Belenky et al. (1986) interviewed 135 women from diverse backgrounds to explain different stages of knowing. Although, very different from Piaget’s developmental stages, these ways of knowing however do “represent a progression from dependence to

autonomy, from uncritical to critical” (p. 165, Becker, 1995). Becker (1995) states that even though Belenky et al. (1986) talk about women’s ways of knowing, “...the word ‘women’ is used to refer to all those individuals who think, come to know, or react in a fashion that is common to the majority of women. These individuals may be females or males. Also, the use of the word ‘women’ to describe the way some people think does not preclude the possibility that some women do not think in this way...” (p. 164).

I will describe in the figure below the interpretations of Belenky and associates’ (1986) ways of knowing as presented by Becker (1995) and Boaler and Greeno (2000) in the context of learning and knowing mathematics. I have merged the two interpretations in some categories and have adapted the explanations provided in Becker (1995) to illustrate the interpretations using examples of statements that the individual at a certain stage of knowing might make in the context of learning mathematics.

Ways of knowing	Interpretation	Example
Silent knowing	Individual considers she is incapable to know and accepts authority's decision as to what is true. Knowing is not vocalized and does not belong to the individual.	My <i>teacher thinks</i> that multiplying 0 by any number gives an answer of 0.
Received knowing	Individual considers her knowledge to be given to her from an authority. She memorizes then mimics/repeats the words of the authority without questioning or understanding the knowledge of the authority.	I <i>know</i> that multiplying 0 by any number gives an answer of 0 because this is a rule given to me by my teacher.
Subjective knowing	Individual derives her knowledge from within herself based on her intuition or affective reactions to information and ideas.	I <i>know</i> that multiplying 0 by any number gives an answer of 0 because it's obvious. It <i>feels right in my gut</i> to think that nothing times something must result in nothing.
Separate knowing	Individual is suspicious of intuitive ideas and often takes an adversarial stance towards it; The teacher is no longer an authority nor does intuition dictate if an idea is to be accepted as a possible truth. Considers her knowledge to derive validity by proving the ideas based on propositional logic. No context is needed.	I <i>know</i> that multiplication by 0 results in 0 but is it always the case? I need a formal proof to believe this statement such as let $x$ be any real number then using the definition of multiplication I need to prove $x \cdot 0 = 0$ .
Connected knowing	Individual considers her knowledge being constructed through shared experiences. Intuition sets the stage to explore patterns and then patterns lead to conjecture. Connected knower contextualizes an idea and interacts with other people or texts to understand the circumstances that lead to a certain conclusion.	I <i>know</i> that it looks like that multiplication by 0 results in 0. But I want to look at how others have reasoned about this statement. For example, I want to know why would others think that if they had \$0 and multiplied it by \$1 then the answer would be \$0? I have looked at the pattern $0 \cdot 1 = 0$ , $0 \cdot 2 = 0$ , $0 \cdot 3 = 0$ ..., what patterns did others look at?
Constructed knowing	Individual considers her knowledge being constructed by merging aspects of connected and separate knowing. Learner appreciates the complexity of knowledge from various perspectives.  She contextualizes an idea, uses intuition to creatively explore various patterns, makes sense of and incorporates others' experiences and reasoning into her own understanding of a concept, then uses rules of discourse and deductive logic to construct her knowledge of the concept. Constructed knower engages in reflecting and describing the process of how the knowing of something occurred for her.	Let's think about what this statement means in different contexts like money, area etc. and why would it be true. Let's look at some patterns involving various types of numbers. What were the circumstances that led others to conjecture this idea? I want to look at how others have reasoned about this statement. Since multiplication is commutative would a reversed situation result in the same conclusion? Now I would like to prove this statement. What axioms would I assume and why? Let me now reflect on how is it that I came to understand that multiplying 0 by any number gives an answer of 0.

Figure 1. Interpretation of ways of knowing

Sources: Becker, 1995 and Boaler & Greeno, 2000

Boaler and Greeno (2000) studied the mathematics learning environments of six different high schools. The participants in their study were taken from AP calculus classes and were all considered successful students of mathematics in their respective schools. However, the results of their study indicate that students from different learning environments developed different types of mathematical abilities that fall into the categories of ways of knowing described by Belenky et al. (1986). Boaler and Greeno (2000) conclude in their study that identity, agency, and ways of knowing in mathematics worlds are “characteristics of students’ adaptations to their mathematics learning environments” (p. 174). In the context of this study, I shall use Boaler and Greeno’s (2000) views to define mathematical competence as the ability to “engage in sense-making and problem solving using and developing mathematical representations, concepts, and methods as resources” (p. 172).

Similar, to Boaler and Greeno’s (2000) AP calculus participants, women who are generally considered successful in mathematics and science are the ones who most likely choose to participate in informal math/science camps or enrichment programs. The question then is whether or not these informal programs improve their knowledge and skills to solve math problems, but it is to investigate the type of mathematical competence these environments co-construct among its participants and how; and to see if the type of mathematical competence co-produced in such environments sustains the interest of its women participants from diverse backgrounds to pursue STEM related higher education and/or careers. The findings of my study related to the construct of mathematical competence or ways of knowing in mathematics will add to the body of literature that extends the concepts and theory proposed by Belenky et al. (1986).

### **MLI - perceptions of self as a learner aspect**

There has been some limited research (e.g. Barton et al., 2013; Morrow & Schowengerdt, 2008; Frost & Wiest, 2007; Fadigan & Hammrich, 2004) on how informal educational programs such as math clubs and science camps aid in a positive learning identity construction for girls. For example, Barton et al. (2013) in their study trace the identity work in science of 40 middle-school girls from non-dominant backgrounds over a period of three years. In their article ‘Crafting a future in Science: tracing middle-school girls’ identity work over time and space’, the authors describe two of the cases from their larger longitudinal case study in detail and note the impact of an after-school informal science club on one of the participant’s (Chantelle) sense of self as she develops confidence in her abilities to do science and engage in discursive practices related to the content of science. Authors ascribe this positive impact to the environment of the Science club that recognized the artistic talents of Chantelle and allowed her to incorporate those talents in a Science related project. Furthermore, the authors note that the shift in the identity trajectory of Chantelle also caused the perceptions of her middle-school Science teacher to change from describing Chantelle as shy and struggling to seeing her as smart and hard-working. Barton et al. (2013) also discuss the implications of shift in the identity trajectories of girls on their vision for their future participation in science, mathematics, and technology fields.

Similarly, Morrow and Schowengerdt’s (2008) study highlights the importance of an informal math program for girls. These authors talk about development of identity in terms of mathematical journeys taken by the participants of their study at a university affiliated math and engineering residential camp, SEARCH. Morrow and Schowengerdt

(2008) conducted a case study involving 12 participants in order gain an in-depth understanding of the SEARCH program to determine the factors that affected pursuit of higher-level mathematics by its participants. The findings of their study indicate that informal math programs such as SEARCH provide a challenging and supportive learning environment, help enhance girls' self-confidence and sense of agency in mathematics, encourage a positive attitude towards risk-taking in mathematics, and foster a broader view of advanced mathematics. In another study, Fadigan and Hammrich (2004) examined educational and career trajectories of a sample of 152 female participants of an informal science program, WINS. Regarding the impact of the program on Science-identity formation, the authors state that the social opportunities such as mentorship, socialization with like-minded peers, providing a safe and stable environment provided by WINS program lead to feelings of greater competency in STEM learning, enhanced resilience, and improved sense of self-efficacy. Even though the focus of Morrow and Schowengerdt's (2008) and Fadigan and Hammrich's (2004) studies is not learning identity formation, their findings do relate to certain aspects of positive identity construction.

However, more research is needed on how summer math camps in particular relate to the mathematics learning identity of girls from minority and/or low SES backgrounds and to identify the particular practices and elements of these learning environments that are valued by this population in having influenced their learning identity.

### **MLI – narratives of gender, race, or class aspect**

There has been some research (McGee, 2015; Zavala, 2014; Nasir et al., 2013; Martin, 2009; Solomon, 2009) that illustrates that discourses on gender, race, class, or national origin that are prevalent in society have implications for learning and identity formation. For example, Nasir et al. (2012) theorize the relationship between race and schooling. In their article ‘Racial Storylines and Implications for Learning’, Nasir et al. (2012) argue that “racial ‘storylines’ or narratives are prevalent in our society and have powerful implications for learners, particularly for youth from marginalized communities” and “these racial storylines are a critical aspect of life in schools, which serve the purpose of racially and academically socializing students.” These authors discuss how racial storylines are invoked in learning settings and the impact they have on students’ identity formation. Nasir et al. (2012) also “consider the potential of alternative spaces” such as out-of-school learning settings in helping students “counter dominant narratives about who is capable of learning.” Similarly, in her book ‘Mathematical Literacy: Developing Identities of Inclusion’, Solomon (2009) considers “the role of class, ethnicity and especially gender in the development of classroom interaction patterns”, illustrating the impact of such experiences on students’ identity development. Another recent and pertinent work on the role of race and learning is from the author Ebony McGee. In her article, ‘Robust and Fragile Mathematical Identities: A Framework for Exploring Racialized Experiences and High Achievement Among Black College Students,’ McGee (2015) analyzed the learning experience of 23 high-achieving African American college students in STEM fields. In her article, the author reported on the experiences of two of black students, Tinesha and Rob, and how these two “students

maintained high levels of academic achievement” in their chosen STEM fields “while enduring marginalization, stereotyping, and other forms of racialization” (McGee, 2015).

The above studies highlight that larger societal discourses play a critical role in students’ learning. Therefore, I consider such narratives to be an important aspect of my construct MLI.

### **Social Capital**

Another factor that has been identified in the literature as having an important effect on people’s educational and career aspirations and trajectories is social capital (e.g. Eagan et al., 2013; Berzin, 2010; Bok, 2010; Lin, 1999; Coleman, 1988; Bourdieu, 1986). In the context of this study, I will use the definition of social capital provided by Lin (1999) who defines it as resources accessed in social networks that depend upon human capital (self/parental education and experiences), initial positions (parental or prior occupational statuses) and one’s social ties (e.g. kin, friends, acquaintances, colleagues, organizations). Lin (1999) conducted a meta-analysis in tracing the development of social resource theory and describing this theory in the context of social capital and socioeconomic status attainment. The relationship between social capital, human capital, and the process of improving one’s socioeconomic standing in society is also discussed. Lin (1999) article on ‘social networks and status attainment’ offers great insight into understanding the construct of social capital and how it relates to status attainment. Eagan et al. (2013) conducted a longitudinal research involving a sample of 4,152 undergraduate students regarding the effect of undergraduate research programs in STEM on students’ intention to continue graduate studies. The authors used status attainment theory (refers to socioeconomic status as an individual’s sense of origin i.e. his/her social standing

measured by parental education and income) as a lens in understanding the factors that affect students' aspirations in pursuing advanced level of higher education and found this lens especially useful when studying the aspirations of students from minority backgrounds. Eagan et al. (2013) also note the importance of Weidman's (1989) theory of college student socialization which states that "as students become socialized into a particular environment, they may begin to be affected by the norms of that social structure...students who socialize with and compare themselves to a set of high-achieving students ...mirror the higher levels of achievement of their peers" (p. 688). This suggests that one's learning environment plays a crucial role in affecting one's educational and career aspirations even if one is lacking academically successful role models in his/her immediate family circle. Robinson and Harris (2014) in their article 'Parental Involvement Is Overrated' discuss the findings of their study regarding the impact of parental involvement on children's academic success. These authors suggest that the best kind of involvement is for parents to communicate the value of schooling and going to college to their children starting early on and keep reinforcing this message over time. But what if one's parent's aren't well educated and do not move in such circles? How might they reinforce such a message and provide academically successful role models for their children? This is where Weidman's (1989) model proves helpful. By exposing their children to learning communities such as informal programs where faculty and peers can serve as role models and the community's resources provide the necessary information (such as applying to colleges, financial resources available to pay for college etc.), parents may be able to help their children realize their educational and career aspirations. The aforementioned studies do not however discuss the construct of

social capital specifically in relation to disadvantaged women's educational and career trajectories in STEM and in the context of unique social settings such as informal math programs. Therefore, more research is needed in this area.

The two constructs – mathematics learning identity (MLI) and social capital (SC) described above may not develop in isolation for an individual in a given learning environment. Therefore, it is important to explore their relationships with each other and with the components of the learning environment. My study hopes to investigate these relationships in the context of the learning environment of an informal math program.

### **Informal Mathematics Programs**

I refer to informal mathematics programs/camps to mean extracurricular math programs such as after school math clubs, enrichment programs, summer camps that focus on educational activities that are not part of standard school curricula and whose purpose is to provide unique learning spaces in which students' interest and talent in mathematics can be further developed. There has been some research (e.g. Morrow & Schowengerdt, 2008; Frost & Wiest, 2007; Fadigan & Hammrich, 2004; Darke et al., 2002) that has identified that participation in summer math and science camps and related extracurricular activities have a positive effect on young women's dispositions towards pursuing higher education and careers in STEM fields. For example, Morrow and Schowengerdt (2008) found that math camps foster a broader view of advanced mathematics and deeper insights into the nature mathematics. Frost and Wiest (2007) found that informal math and science programs have a positive impact on knowledge, dispositions, and participation in math and science among girls. These and other studies (e.g. Turner & Tigert, 2010; Wiest, 2008) found that informal mathematics programs tend

develop positive attitudes towards mathematics and promote mathematical discourse, encourage collaboration, and develop persistence.

Several informal math and/or science programs (e.g. RMP, PROMYS, SEARCH etc.) are affiliated with universities (e.g. Ohio State, Boston University, Mount Holyoke, etc.) and offer residential summer programs for high school students. As part of my research I have chosen to study in-depth one such program, RSMC, and explore its practices and characteristics from the perspective of its women participants from low SES and/or minority background; and how these practices impact the education and career choices of this population.

### **The Program of Study – RSMC**

In this section I shall extend the description of RSMC from chapter 1 to give more details about its vision for learning. I shall elaborate more on its student demographics, particular structure and practices over the years in chapter 3. The information that is provided by here and in later chapters about RSMC such as its philosophy, structure, and demographics comes from the RSMC website and from an interview that I conducted with the RSMC director.

RSMC, founded more than 25 years ago, is an intensive multi-summer math program for high school students. It is a residential summer camp, which is held every year at the campus of a university in southern United States. RSMC was created to (a) excite young students about the joy of mathematical exploration and discovery, (b) help young students realize their full potential by nurturing students in a unique learning environment where everyone is encouraged to grow and develop through the experience of working together, (c) teach students simply for the joy of learning and working

together, without the pressures of worrying about grades or covering a certain amount of material. Students are taught by university faculty and mentored by undergraduate counselors who often tend to be RSMC alums. RSMC students are expected to be active participants in doing math. They are not told procedures rather they must work out why things work for themselves from first principles. Students are encouraged to understand the simple ideas behind why complicated problems work, to “think deeply of simple things.” It is through this deep understanding of basic principles RSMC expects its students to attack even the hardest problems some of which are at the level of graduate mathematics.

The typical ratio of boys to girls in the program is 1:1. RSMC also offers camp scholarships based on financial need and every effort is made to ensure students can attend regardless of their financial background. RSMC’s vision for the future is to make the camp a rich experience for all students, to learn from students who do great things coming from humble backgrounds, and to show that there is talent everywhere, and provide a “proof” that this talent can be nurtured when all students have opportunities to learn in a safe and supportive environment.

### **Gap in the Literature**

Efforts are being made to increase girls’ and women’s participation in STEM and narrow the gender gap through various after school programs, informal math and science programs such as university affiliated summer camps, and mentoring programs (Fadigan & Hammrich, 2004; Morrow & Schowengerdt, 2008). There have been some studies (Barton et al., 2013; Darke et al., 2002; Fadigan & Hammrich, 2004) that have identified math and science summer camps, after school math or science clubs, and mentoring

programs as having a positive effect on girls' self-concept and learning identity with respect to STEM related fields. These studies and others (e.g. Dweck, 1986 as cited in Boaler, 2002) however present their findings in the light that focuses on improvement of characteristics of the individuals rather than explaining the findings in the light of responses of individuals to the affordances of the environment (Boaler, 2002).

Underachievement of Latina/o or Black students in math is often framed as “race-based” testing outcomes and seldom explored from the perspective of these students' lived experiences in math classrooms (Zavala, 2014; Martin, 2009). Therefore, more research on equity issues such as gender and SES is needed from the point of view of examining the characteristics of a learning environment through the perspective of its participants and how a certain population of participants such as girls from low SES and/or minority backgrounds responds to these characteristics.

In addition, there have not been any studies that I have come across which explore the interaction of the constructs – mathematics learning identity and social capital and their development within a given learning environment. There exists a gap in the literature regarding how informal educational programs in general and math summer camps in particular may co-produce and influence the aforementioned constructs, affecting women's educational and career choices and trajectories with respect to STEM related fields. Furthermore, there hasn't been much research on classifying the characteristics of such camps and determining the role of such avenues on educational and career choices of young women from minority and/or low SES backgrounds (Morrow & Schowengerdt, 2008; Fadigan & Hammrich, 2004). This in itself is a crucial part of the problem. Therefore, I argue that there is a need for this study to shed some

light on the aforementioned issues and to establish an equity-based educational model for (a) understanding the role math camps play in co-constructing and influencing the factors such as mathematics learning identity and social capital that may impact girls' and women's aspirations to pursue a STEM related higher education and/or career; and (b) to identify and gain a better understanding of the characteristics and long-term effects of such programs on the educational and career choices made by young women from minority and low socio-economic backgrounds from the perspective of this population.

### **Theoretical Framework**

Towers and Hunter (2010) define ecological perspective as “an ecological model of the classroom [in which] everything is connected; who we are depends on who and what we are interacting with and the individual is re-conceived as an interdependent member of a larger and more complex mental ecology (Bowers, 1995; Barab & Roth, 2006 as cited in Tower & Hunter, 2010)...” (p.27). This perspective informs and is informed by the situative learning theory and theory of perceptual affordances. Greeno and Gresalfi (2008) state that the main focus of the situative perspective is on how learning takes place through interaction of an individual between the elements (e.g. peers, teachers, materials, and informational resources) that are present in a setting or community. Greeno and Gresalfi (2008) call this interactive setting an activity system. “In this view, learning by an individual in a community is conceptualized as a trajectory of that person's participation in the community - a path with past and present, shaping possibilities for future participation...” (Greeno & Gresalfi, 2008, p. 170). Conceptualizing learning this way then depends on the opportunities (affordances) to learn that an activity system or a community offers to its members (Greeno & Gresalfi,

2008). Gresalfi (2013) also explains the concept of affordances as a set of actions that are made possible by a particular environment or an object. For example, a chair affords sitting and a doorway affords passing through it. An affordance is relational (depends upon an individual's relation with the system), relative (differs from person to person), and is characterized by the resources and practices of an activity system. The extent to which an affordance is acted upon depends on the individuals' ability (effectivities) to recognize and realize it (Greeno & Gresalfi, 2008). For example, just because a chair affords sitting doesn't mean that one may or even can sit on it (Gresalfi, 2013).

Furthermore, what makes an affordance actionable depends upon the dynamic interactive relation between an individual and the activity system/environment. In other words, affordances are relationships between characteristics of the environment and the characteristics of the individual (Greeno & Gresalfi, 2008). Therefore, an individual's learning identity may certainly be influenced by this interactive relationship between the learner (what he or she brings to the interaction) and the resources and opportunities afforded to the individual by the system as a result of this interaction (Greeno & Gresalfi, 2008).

Extending upon the work of Boaler and Greeno (2000), Boaler (2002a, 2002b), Greeno and Gresalfi (2008), Towers and Hunter (2010), and Gresalfi (2013), I shall consider RSMC as a learning community or an activity system and consider the nature of its affordances with respect to its relation with a camper's mathematics learning identity and social capital from the perspective of its female participants from economically disadvantaged and/or minority backgrounds. Traditionally in mathematics education research, the situated ecological perspective has been used to study the constructs such as

cognition, learning identities, knowledge development and the environments in which they operate (Boaler, 2002a; Boaler & Greeno, 2000; Gresalfi, 2008, 2013; Towers & Hunter, 2010). However, my use of this perspective in studying the construct of social capital and its relationship to the participation of female students of a math camp in pursuing STEM related education and/or careers would constitute a novel extension of this framework. In this way, the situated (situative) and ecological perspective helps me to conceptualize an operational framework for studying the relationships my constructs have with the learning environment – RSMC that may engender and/or influence these constructs for its participants. Furthermore, the framework also provides for identifying the particular elements/practices of RSMC valued by its women participants from economically disadvantaged and/or minority backgrounds as a set of affordances (opportunities/relationships that resulted from the interaction between certain characteristics of RSMC and certain characteristics of this particular population of its participants). The ecological perspective provides a theoretical framing of my study. However, in order to operationalize this theoretical perspective, I made use of Nasir and Cooks' (2009) identity resource model to analyze my data. This model allows for thinking about how learning settings provide resources for development of practice-linked identities in a more concrete manner. As part of their model, Nasir and Cooks (2009) highlight three kinds of resources (defined below) that accumulate overtime and have implications for identity development in a practice:

- material resources (the physical artifacts in the setting)
- relational resources (interpersonal connections to others in the setting)

- ideational resources (ideas about oneself and one's relationship to and place in the practice and the world, as well as ideas about what is valued and what is good)

The authors illustrate how the above identity resources were made available in a learning setting where the practice was track and the participants were students learning to become athletes. However, I used their model to analyze my data for the development of MLI in a learning setting of an informal program where the practice is mathematics. Furthermore, I also extended the use of this model when analyzing my data for the construct of SC in order to determine what type of resources were offered at RSMC that impacted the education and career trajectories of the participants in my study, if any.

### **Summary**

This chapter reviews the pertinent literature surrounding the research questions for my study and presents my theoretical framework. A summary of this chapter is provided below.

There has been some limited research (e.g. Barton et al., 2013; Eagan et al., 2013; Morrow & Schowengerdt, 2008; Frost & Wiest, 2007; Fadigan & Hammrich, 2004; Boaler & Greeno, 2000) that either directly or indirectly shows how different learning environments (such as informal math/science programs, math classrooms, college settings) aid in a positive learning identity construction for students and/or affect their social capital. However, the constructs – mathematics learning identity and social capital as described in this chapter may not develop in isolation for an individual in a given learning environment. Therefore, it is important to explore their relationships with each

other and with the components of the learning environment. My study investigates these relationships in the context of the learning environment of an informal math program.

The situated (situative) and ecological perspective and the identity resource model as described in this chapter helps me to conceptualize an operational framework for studying the relationships my constructs have with the learning environment – RSMC. Furthermore, the framework and the model also provide for identifying the particular elements/practices of RSMC valued by its women participants from diverse backgrounds as a set of affordances (opportunities/relationships that resulted from the interaction between certain characteristics of RSMC and certain characteristics of this particular population of its participants).

### **III. METHODOLOGY**

In this chapter I shall describe my research methodology in order to address my research questions. The chapter is divided into the following sections:

- (1) Research Design Overview
- (2) Informal Mathematics Program Site
- (3) Participants
- (4) Data collection and Data analysis
- (6) Trustworthiness

#### **Research Design Overview**

##### **A Case Study Research Methodology**

As described in Chapter II, my analytic lens for this study is informed by the ecological and situative perspective. Using this lens, I view an individual's mathematics learning identity and social capital as co-constructions resulting from the interaction between the individual and various contexts. In this work, I will focus on the context of a particular learning environment, RSMC. The reasons for choosing this particular math camp for my study are discussed in the section Informal Mathematics Program Site.

Several authors such as Merriam (1988; 2009), Stake (1995), Yin (2009), and Creswell (2013) have written a large array of texts explaining the case study approach to research across various disciplines. Creswell (2013) defines case study as:

A qualitative approach in which the investigator explores a real-life, contemporary bounded system or multiple bounded systems over time, through detailed, in-depth data collection involving multiple sources of information, and reports a case description and case themes (p. 97).

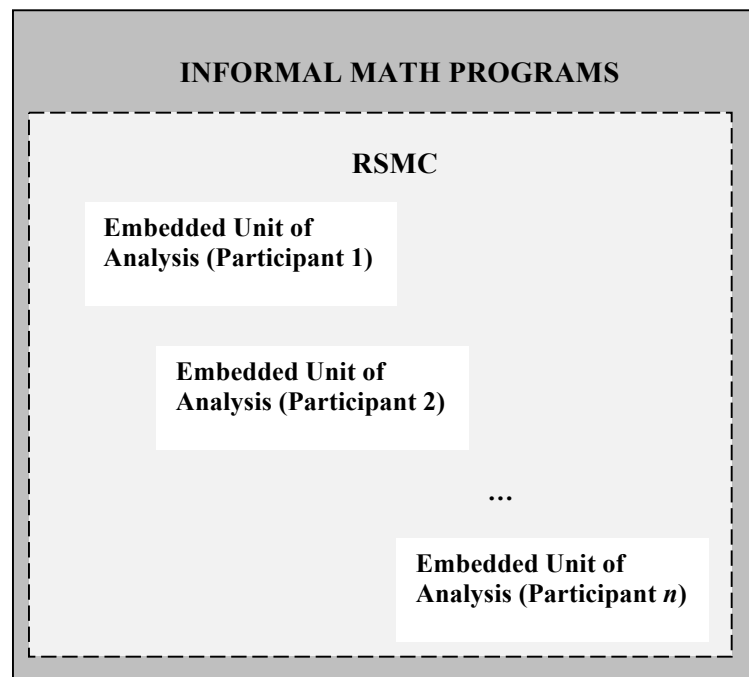
Similarly, Stake (1995) points out that “The case is a specific, a complex, functioning thing...a bounded system” (p.2). He further adds that in the discipline of social sciences (such as education) a case is likely to be purposive and constitutes a system. Therefore, programs and people are clear candidates for being perspective cases (Stake, 1995). Furthermore, Schramm (1971) as cited in Yin (2009) observes “The essence of a case study...is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result” (p. 17). In this study, RSMC constituted a bounded system (a specific, complex, functioning program). And in my study of it, I illuminated the effect of this system’s practices and various components as envisioned by its participants on the constructs of MLI and SC. I also described how this envisioned impact of the system contributed to a set of STEM related educational and career decisions taken by its former women participants from diverse backgrounds. In particular, I brought to light why these decisions were taken and according to the participants how RSMC affected this decision-making process, if at all. Furthermore, I identified the particular elements or characteristics of the RSMC program that were valued by the participants and led to the impact on their MLI and SC. This was done by conducting an in-depth investigation of RSMC and its components through the perceptions of its women participants utilizing multiple sources of data (interviews, journals, and documents). This description of what I studied (a program, an entity and its effect on a decision-making process of its women participants) fit well with the definition and characteristics of a case study research method as mentioned above by Schramm (1971) as cited in Yin (2009), Creswell (2013), and Stake (1995). Yin (2009) also suggests that case studies, histories, and experiments are the preferred research methods

when “how” and “why” questions are being posed because “such questions deal with operational links needing to be traced over time, rather than mere frequencies or incidence” (p. 9). Furthermore, if the focus is on contemporary real life events (such as a set of decisions, behavior of a small group, practices of an organization, tracing interpersonal events like career advancement over time), the investigator has little control over the behavioral events, and collecting data through interviews or observations of the persons involved in the events is crucial to the study, then case study is the more appropriate and preferred choice for a research method (Yin, 2009). This explanation of Yin (2009) about when case studies are considered an appropriate method to conduct research fit well with the types of research questions I studied. The focus of my study is on contemporary real-life events – a program’s envisioned effect on factors that influence education and career choices of women, a set of decisions to pursue STEM education and careers by female campers of a program, practices of a summer camp that contributed to this decision-making. In addition, the retrospective nature of the study required tracing the educational and career trajectories of former female participants of RSMC from the time they were campers during high school to the present. Thus on the basis of the above, I concluded that the in-depth investigation of RSMC as an informal math program with respect to the role it played in shaping the educational and career trajectories of its women participants, if any, was best suited for a longitudinal, exploratory, and descriptive case study research methodology with RSMC being the case. The case study is exploratory and descriptive in nature because it entailed exploring and then providing descriptions of the educational and career trajectories of former female participants of the

RSMC and their perceptions about the role RSMC played, if any, on their decision making with respect to their educational and career choices.

### **Type of case-study design: embedded**

The research questions of this study led to choosing the main unit of analysis (or the single case) in this work as RSMC, a learning environment. Yin (2009) explains that when a single-case is studied through analyzing data about subunits that are embedded in the case (such as studying an organization through its employees or a school through its students) to better understand certain aspects about the main unit of analysis (the case), then such a design is called an embedded case study design. My study was most conducive to a single-site embedded case study design where RSMC formed the main unit of analysis and its women participants from diverse backgrounds constituted the embedded units of analysis. The figure below comes from Yin (2009) and is adapted to represent the design of my case study:



*Figure 2.* Yin's 2009 single-case embedded (multiple units of analysis) case study design

## Informal Mathematics Program Site – RSMC

I selected RSMC as my case for this study because it was easily accessible to me due to its proximity and my working relationship with its staff, which was crucial in gaining access to camp’s participants and the various data sources essential for this study. In addition, RSMC was established more than 25 years ago, has a 1:1 ratio of girls to boys, and offers need-based financial assistance to applicants. This met the criteria for my research which focused on studying a longitudinal case to better understand the long-term effects of informal math programs on the educational and career trajectories of young women from diverse backgrounds in a mixed-gender setting. The description I provide here speaks more to the specifics about the structure of the camp itself. The purpose of this description is both to explicitly explain the structure of the camp and to define all the necessary pieces that I will refer to later in other sections of this chapter. Below I first describe the typical day/week structure for students at the camp.

	1st-year Students (first-time students)	2nd-year Students (returning students)	3rd-year Students (returning students)
7:00-8:00am	Breakfast		
8:15-9:45am	Number Theory		
9:50-10:50am	Honors Seminar	Research Projects Research Projects	
10:55-Noon	Guest Speakers		
Noon-12:40pm	Lunch		
12:45-1:45pm	Problem Session/Mathematica Lab	Combinatorics	Analysis II
1:50-2:50pm	Problem Session/Mathematica Lab	Analysis I	Abstract Algebra
3:00-5:00pm	Recreation and Free Time		
5:00-6:00pm	Dinner		
6:00-10:00pm	Study Group		

*Figure 3.* RSMC campers’ typical daily schedule (Monday – Thursday)

	1st-year Students (first-time students)	2nd-year Students (returning students)	3rd-year Students (returning students)
7:00 - 8:00am	Breakfast		
8:15 - 9:45am	Number Theory		
9:50 - 10:50am	Honors Seminar	Research Projects Research Projects	
10:55 - Noon	Free time		
Noon - 12:40pm	Lunch		
12:45 - 1:45pm	Problem Session/Mathematica Lab	Combinatorics	Analysis II
1:50 - 2:50pm	Problem Session/Mathematica Lab	Analysis I	Abstract Algebra
3:00 - 4:00pm	Recreation and Free Time		
4:00 - 5:00pm	Colloquium (Guest Speakers)		
5:00 - 6:00pm	Picnic and barbeque (local park)		

Figure 4. RSMC campers' typical Friday schedule

On weekends students go on trips with their peers, counselors, and professors. Some of the activities on these weekend trips include – camping on a ranch, hiking, river-rafting, and watching a play at an open theater.

I have divided the various components of RSMC into three categories – people, curriculum, and structure. These components are defined below based on the information that I obtained from RSMC's office and the camp's website.

I. People – people are the life of RSMC and assume different roles in the functioning of the camp.

a. *Campers* – form the student body of RSMC and are expected to be active participants in doing math. A maximum of 60 campers are accepted each year with approximately a 1:1 ratio of girls to boys. The application process entails completing an application and submitting a personal essay, a teacher recommendation, and school transcript. Beyond a strong recommendation and good academic standing, the RSMC admissions committee looks for curiosity and an interest in figuring out problems, persistence and a desire to

learn that goes beyond what is expected in school, a spirit of working with others, and students who seem to show potential, but may not have had the opportunity to grow and develop in mathematics. RSMC's philosophy is to encourage learning for the love of learning in a nurturing non-competitive environment. Students from all over United States as well as some international applicants from various countries such as Indonesia, Spain, China, Albania, and Hungary, among others are accepted into the program. The following tables and pie charts describe the demographics of the student body make up of RSMC over the years 1990 – 2008:

Table 1  
*Number of male and female students over the years 1990 - 2008*

Year	Male	Female	Total
1990	8	8	16
1991	10	8	18
1992	19	20	39
1993	19	21	40
1994	26	25	51
1995	27	26	53
1996	23	24	47
1997	24	25	49
1998	27	21	48
1999	22	26	48
2000	25	27	52
2001	26	27	53
2002	30	28	58
2003	28	22	50
2004	32	20	52
2005	25	26	51
2006	26	26	52
2007	26	30	56
2008	31	26	57

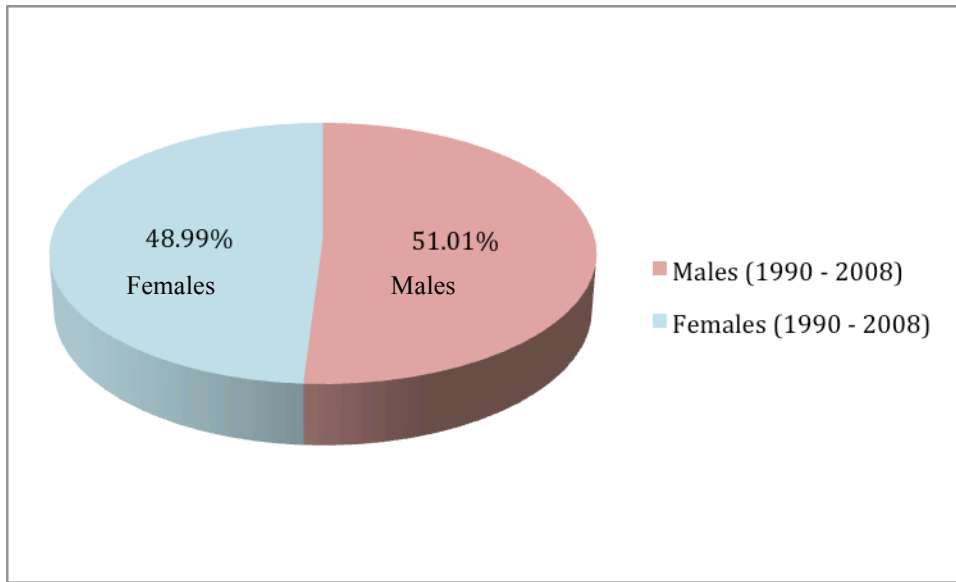
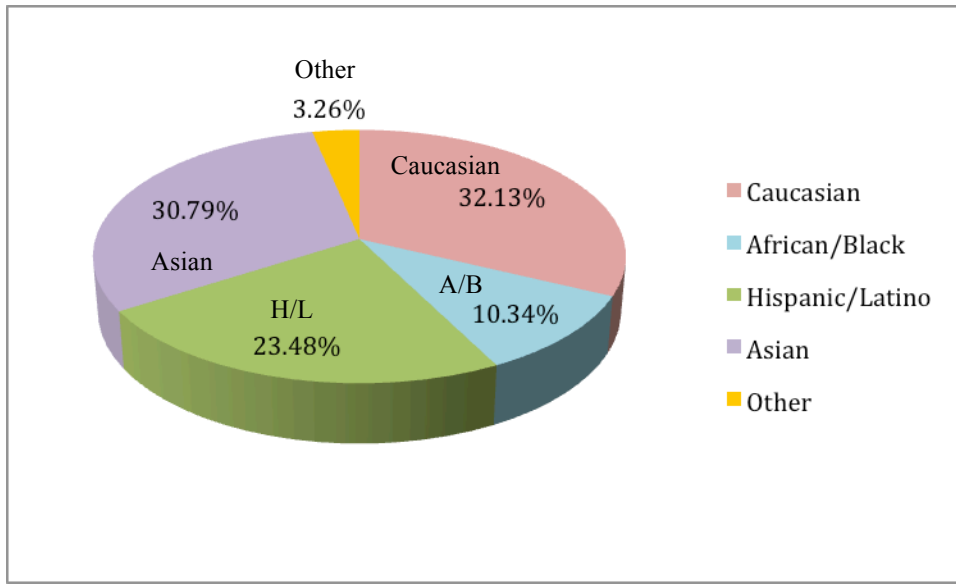


Figure 5. Percentage of female and male students over the years 1990 – 2008

Table 2

*Number of students in different ethnic groups over the years 1990 – 2008*

Year	Caucasian	African/Black	Hispanic/Latino	Asian	Other	Total
1990	7	5	3	0	1	16
1991	10	6	2	0	0	18
1992	16	3	11	5	4	39
1993	11	4	13	9	3	40
1994	15	5	17	11	3	51
1995	17	7	16	13	0	53
1996	14	3	17	12	1	47
1997	20	6	13	9	1	49
1998	25	5	9	9	0	48
1999	22	5	7	14	0	48
2000	22	3	9	18	0	52
2001	17	7	14	15	0	53
2002	13	9	22	14	0	58
2003	14	4	10	20	2	50
2004	18	1	6	27	0	52
2005	11	4	12	23	1	51
2006	11	1	8	26	6	52
2007	13	7	10	23	3	56
2008	10	7	10	26	4	57



*Figure 6.* Percentage of students in different ethnic groups over the years 1990 – 2008

b. *Junior counselors* – are students who are attending the RSMC for their third summer. They are considered “camp counselors in training”. They help camp counselors review students’ problem sets, as well as receive experience in counseling a study group (see below) during the first 45 minutes of study group sessions. There have been times when some enterprising and eager second year campers have expressed interest in serving as junior campers and have been allowed to do so.

c. *Counselors* – RSMC recruits approximately 15 camp counselors each summer, with each counselor assigned to a study group of 3-5 students. . Two of these camp counselors - one male and one female are designated as head counselors since they have additional duties besides serving as counselors to their assigned study group. The head camp counselors are in charge of all the other camp counselors, and for much of the day-to-day running of the program. The camp counselors are selected by the program director in

consultation with the faculty and generally tend to be camp alumni who are pursuing undergraduate studies.

d. *Administrative staff* – the staff are responsible for the day-to-day operations of the camp, which is year-round work. Some of responsibilities of the administrative staff include fundraising (to support camp scholarships), scheduling field trips and weekend trips for campers, looking after campers' and counselors' meal arrangements, processing camp applications, and communicating with students and parents. Basically, the staff does all the “behind the scenes” work to ensure a smooth and successful running of the camp.

e. *Faculty* – these are primarily the university faculty who teach various courses at the camp and also mentor the second and third year students on their research projects. Some faculty and mentors are from nearby universities or local industry with a strong interest in research.

II. Curriculum – the following courses comprise the curriculum for the camp. The content and instructional material for the courses is developed at RSMC in collaboration with each faculty teaching the course.

a. *Number Theory* - this course covers basic properties of integer arithmetic, including unique prime factorization, Euclid's algorithm, Diophantine equations, modular arithmetic, congruence, induction, well-ordering, quadratic-residues and quadratic reciprocity. This is a first year course that provides a solid foundation for all students in mathematics. A sample problem set from this course is included in Appendix D. If returning students wish to re-attend this course, they are encouraged to do so. Second and

third year students who are serving as junior counselors (see below) sometimes attend this course to familiarize themselves with the new first year campers.

b. *Honors Seminar* - is an interdisciplinary first year course that stresses teamwork but is not a content course in math. This course challenges students intellectually through rigorous standards of analysis, debates, and philosophical discussions. Hands-on learning experiences introduce students to concepts of teamwork and critical thinking. Reading discussions and guest speakers add fundamental and thought-provoking theories from multiple perspectives. In the recent years, the capstone project for the course is an entrepreneurship activity that includes a final group presentation. This entrepreneurship activity entails the first-year campers collaborating with the members of their study group (see below). This is a team-building activity in which campers working together as teams come up with an innovative business idea that incorporates a combination of concepts from math, science, and technology, develop it, and then pitches it to a panel of judges at the end of the six weeks. However, it must be noted that the entrepreneurship activity was not part of RSMC curriculum from 1990 – 2008 and is only a recent development.

c. *Mathematica Computer Lab* – this is a first year course that enables students to explore the application of ideas discussed in the Number Theory and Honors seminar courses. For example, when an algorithm is discussed in Number Theory, this same algorithm is explored and implemented in Mathematica Lab. This Lab provides a vehicle for exploring data and looking for patterns, which would then be discussed and proved in Number Theory, Honors seminar, or problem sessions. Furthermore, students use the Mathematica software to model real world problems. Specific applications include Euclid's algorithm, solving Diophantine equations, the Chinese Remainder Theorem,

modular arithmetic, public key encryption, testing for primality, and Gauss's Law of Quadratic Reciprocity, among others.

d. *Combinatorics, Analysis I&II, Abstract Algebra* – these constitute second and third year courses and provide returning students with a firm foundation in fundamental areas of advanced mathematics, while building on ideas from the first year. In the early years, Combinatorics and Problem Solving was offered as a first-year course, but for the past 10 years it has been a second or third year course.

e. *Research projects* – research projects were not always part of the RSMC curriculum, but were introduced in 2001, providing second and third year students with an opportunity to work on original math/science research projects. This gives students experiences in original research, creating their own new theories and breaking new ground in math and science. During the school-year, RSMC recruits a number of faculty members to serve as research mentors. These research mentors provide research topics and guidance for the students on their research projects. RSMC administrative staff assigns groups of research teams to each mentor, based on student preferences. Each team is made up of two or three students. The students meet with their mentor two or three times a week, and work on their research topic for the duration of the six weeks. These projects once complete may be submitted to various contests and for publications to various scholarly journals.

### III. Structure

#### a. Student support activities/services

i. *Journals* – the primary purpose of the journals is to let the camp director know exactly what is happening in camp. This enables the director to quickly find out if

there are problems to address. Journals also help the camp director get to know the campers better, see how the study groups are working together, determine if everyone is involved, and ensure that every student is growing and learning from the summer experience. This way journaling serves as a student support activity through which the students can communicate any issues they may be experiencing directly to the RSMC director. A more detailed description of journals is given in the Procedures section below.

ii. *Counselors* –counselors serve as mentors to the campers and provide counseling to campers about any issues they may be experiencing. They live in the dorms with the campers.

iii. *RSMC administrative staff* – the staff also provides student support services and campers may communicate their experiences or any help they need to the staff members. The staff then ensures that the campers get the appropriate support they need.

b. Academic activities

i. *Lectures* – first year students attend lectures in Number Theory, participate in Honors seminar, and attend a computer lab where they learn to program using Mathematica. Second year students attend Combinatorics and Analysis I lectures in the afternoon while they work on their research projects during the morning. Third year students attend Analysis II and Abstract Algebra lectures in the afternoon, while their mornings are also reserved for working on the research projects. The schedule of courses has changed somewhat over time, since Combinatorics was a first year course in the early years, and Abstract Algebra

was for all returning students. However, in the past few years, the schedule above has been followed.

ii. *Problem sessions* – are a time for review of the morning’s lectures, for campers to present their work from the previous night’s Study group session (see below), and for campers to explore new problems that they would like to discuss together. This is an afternoon activity which takes place after lunch from 12:45 pm – 1:45 pm or 1:45 – 2:45 Monday – Friday. Two study groups are combined to make up a problem session and each problem session is led by two camp counselors.

iii. *Study groups* – campers are divided into groups of three or four (and occasionally 5) to form a study group. Each study group is assigned a senior counselor and a junior counselor (junior counselors rotate with different study groups every 3 weeks). RSMC’s program director and assistant director determine the makeup of each study group and assignment of counselors. Study group sessions are held at night from 6:00 pm – 10:00 pm Monday – Thursday and Sundays. The purpose of these sessions is for campers to work together collaboratively on the day’s problem sets (homework) received during lectures. Students may work either individually or as a group on the problems. Often the students will discuss their ideas together at a chalkboard in their classroom. The students then write up their own individual solutions for the problem sets. The counselors with the help of junior counselors aim to ensure that the study group sessions foster camaraderie among group members and create an environment of mutual support to provide a team-building experience. Camp teachers also make their evening rounds visiting with various study groups and offering help. This

structure also allows for students to spend enough time to struggle with the problems in a supportive environment.

iv. *Guest speaker session and Colloquia* – following each Honors seminar there is a Guest speaker session from 10:55 am – 11:55 am Monday – Thursday. On Fridays this session is held at 4:00 p.m. and is referred to as the colloquium.

These sessions are considered a component of the Honors seminar course. The guest speakers from various fields (academia, business, industry) are invited by RSMC to give a talk during these sessions, interact with students, and provide challenging and stimulating questions for campers to work on. The speakers themselves also serve as role models in science, mathematics, engineering, technology, and business.

c. Non-academic activities

i. *Weekend trips* - on weekend students go on trips with their peers, counselors, and professors. Some of the activities on these weekend trips include – an overnight stay at a nearby ranch and work on a conservation project, hiking, tubing or rafting on the river, and watching a play at an open theater. These trips are considered to be valuable team building activities. For example, students who show particular strengths figuring out math theorems may be unfamiliar with hiking outdoors. These trips allow different students opportunities to use other skills, as well as provide a setting for students to work together.

ii. *Friday barbeque picnics* – the colloquium every Friday afternoon is followed by a picnic and barbeque with games and socializing at a local park.

iii. *Recreation time* - this refers to the free time that students have during the week. All students have full use of the University's Student Recreation Center, which offers basketball courts, volleyball courts, racquetball courts, an indoor track, and a swimming pool. During their recreation time students tend to relax or exercise or pursue some other activity of their choice.

d. Social network support – RSMC has a monthly e-newsletter that is send to all alumni, parents, and friends. RSMC also has a facebook group, which is a recent development. The assistant director of RSMC keeps in touch with many of the camp alumni through the alumni network that he has established. One of the strengths of the RSMC alumni network is that they have alumni at many of the top-ranked colleges across the nation. This provides a welcoming environment for RSMC graduates who are about to enter college.

### **Participants**

The population for this study is the set of the young women from low SES and/or minority backgrounds who participated in RSMC during their high school years. Because the design of the study is longitudinal, I will make an attempt to select participants who attended RSMC at different points in time during the years 1990 – 2008. The selection of a purposive sample of the potential participants who meet the criteria for my study from the population of interest will be accomplished in the following phases:

Phase 1: In this phase, I sent out a preliminary survey (Appendix A) to all the alumni of RSMC with the help of RSMC staff. The survey was designed to help identify if the participants meet the criteria for my study or not. I also talked to RSMC staff and faculty for suggestions of participants who they recall might meet the criteria for my study.

Based on these suggestions and the survey responses, I created a potential participant database that contained all the pertinent information that was available about the participant such as their journals, camp evaluations, camp essays, faculty and staff correspondence, and any other documents. Following is the template of a record from this database:

Table 3  
*Potential participant database record template*

Name: Jane Doe	
Current professional status	Software Engineer at Apple
Contact information	Current email: <a href="mailto:janedoe@apple.com">janedoe@apple.com</a>
Years at RSMC	3 years: 1999, 2000, 2001
Years for which Journals are available	2000 and 2001
Responded to RSMC alumni survey	Yes.
Years for which Camp evaluations or essays are available	2000 and 2001
Years for which correspondence are available	None.
Faculty and staff correspondence available	Abc: 1 thank you note, 2 pertinent emails Cde: 1 thank you note...
Camp Faculty	Abc for Number Theory, still works at RSMC Contact info: current email - <a href="mailto:Abc@xyz.edu">Abc@xyz.edu</a> , phone# Bcd for Analysis I, still works at RSMC Contact info: current email - <a href="mailto:Bcd@xyz.edu">Bcd@xyz.edu</a> , phone#...
...	...

Phase 2: Once I had a list of potential participants, I then contacted each of the respondents through email introducing myself, describing the purpose of my research, and inviting them to participate in my study. At this point I also elicited the help of

RSMC staff and faculty to encourage the potential candidates to participate in my study. Once I had received the consent from the respondents, I chose 4 respondents as participants in my study based on the following:

- if their responses on the preliminary survey provided rich accounts
- if their journals contain rich descriptions; and
- if their potential participant data base (described in Phase 1) was mostly complete with several data sources.

### **Data Collection and Data Sources**

My research questions and the theoretical framework inform the data collection and data analysis procedures. Data for this study will be collected through multiple sources such as participants' journals during the time they attended the math camp, interviews, preliminary survey, and documents (e.g. camp evaluations, correspondence with RSMC staff and faculty). The main sources of the data will be the journals, camp evaluations, and the participant interviews. Other supporting sources of data may include the preliminary survey and various aforementioned documents. Below I describe each of my data sources in detail.

#### **Preliminary survey**

The design of RSMC alumni survey (see Appendix A) was informed by the purpose of my study. However, the survey was sent to all RSMC alumni irrespective of gender via email and is available online through google drive. A disclaimer was included in the survey alerting the respondents to the fact that their responses on the survey will be used for a research project in mathematics education. This disclaimer was made even more explicit in the cover letter that was sent along with the survey by the director of the

camp stating that the participant responses will be used by one of the graduate students in Math Education who is working on her Ph.D. Since many of the initial admissions applications of campers from the years 1990 – 2008 were missing, I designed this preliminary survey with the help of RSMC director and other staff members for the main purpose of obtaining this missing information to help in participant selection for my study. A secondary purpose for the survey was to help me design interview questions for the participants based on the types of responses I received on this survey. Furthermore, because this study was conducted in retrospect, the preliminary survey helped in establishing the time-line of participants' views over time by serving as a data source in the present. There were a total of 15 questions on the survey. Questions 1 – 8 were related to background information such as name, gender, level of parental education and occupation, eligibility for free and reduced lunch during school, and whether or not the participant is a first generation college student. These questions helped establish the socio-economic status of the participant at the time they attended RSMC as well as provided pertinent background information with respect to their parents' level of education and the type of occupations. Questions 9 – 10 asked about the math courses taken before college. This information was useful in determining if the participants took upper level math courses in high school after attending RSMC to help determine if the camp affected their mathematical competence, which may have contributed to the taking of upper level math courses. Questions 11 – 13 traced the education and career route that the participant took after high school. These questions helped determine if the participant pursued or attempted to pursue STEM related education and/or career after leaving RSMC and helped in participant selection. Questions 14 – 15 gather information about

the RSMC experience and the particular aspects of camp that may have influenced the participants' higher education and/or career choices. These questions helped in identifying the particular characteristics of RSMC that are valued by its campers and that may have contributed to the participants' decision making with respect to pursuing a STEM related education and/or career by influencing the constructs for this study.

### **Interviews**

Interviews with the participants (see Appendix B) constituted one of my primary data sources for each of my research questions. These interviews helped me gain information from the perspective of the participants about the long-term effects of informal math programs like RSMC on the education and career trajectories of its female students. For each of my research questions participant interviews served as a data source in the present, which allowed me to better understand the RSMC experience and its impact on the participants' education/career choices in hindsight at the present point in their lives. The interviews also served as a data source in retrospect which allowed me to analyze the participants' recollections of their past experiences at RSMC and what they thought about its impact then. This way the interviews helped in establishing the timeline of the participants' views. These interviews were semi-structured and had 3-4 parts. These parts focused on each of my constructs and my research questions. These interviews were conducted over Skype and in three cases a follow up interview was conducted via email.

## **Documents**

The documents that constituted the main and supporting data sources for this study include journals, camp evaluations, camp essays, and correspondence with RSMC staff and faculty. Below I provide a detailed description of each.

a. *Journals*: All campers as well as counselors keep journals during their stay at RSMC. Once a camper leaves RSMC his/her journal is photocopied by the camp staff with the consent of the camper and it is understood by the camper that their journal copy is considered the property of the camp. In the recent years at RSMC, journaling has become an online activity instead of the traditional hardcopies. In these journals campers primarily record their day-to-day experiences during camp. Journals are a weekly ritual in the camp. Everyone writes about their experiences and then share these thoughts with the camp director on a weekly basis every Friday, who then reads each journal over the weekend and responds to each camper's comments by the following Monday. He sometimes asks further questions or expresses his own thoughts about what the camper has written. Campers write on a range of topics such as what they are learning in their camp classes, their experience with their study group members, their experience with their peers, their experience of team-building activities and weekend trips organized by RSMC, among other things. According to the camp director the purpose of journals is to inform him about what is exactly happening in the camp, to see how the groups are working together, and if everyone is involved, to address any issues, to get to know the campers better, and to make sure that every student is growing and learning from the summer experience. Although campers are not given explicit prompts, they are however encouraged by the director to write in their journals about their classes, how they work

together in groups, talk about their problem sessions, colloquia, and weekend activities i.e. any and all parts of the camp.

I consider the participant journals a rich data source from the time when they were adolescents attending math camp. This helps in establishing the time-line of campers' views over time by serving as a data source from their past. The information that campers write about in their journals as described above directly relates to my constructs for this study. Their experience and thoughts during camp provide a glimpse into how their learning identity might be shaping, their mathematics ability developing, and what social connections the young campers may be forming. Furthermore, their descriptions of certain aspects of camp that they like also help identify the particular characteristics of RSMC that are valued by the campers.

b. *Camp Evaluations and Essays*: RSMC evaluations are given to campers as a last problem set or assignment (see Appendix C). The purpose of the evaluations is for RSMC to evaluate the camp i.e. to understand what works and what doesn't in order to improve various components of the camp such as courses, colloquia, problem sessions etc. Evaluations also help determine how the camp affects the students and how students grow through the experience. Evaluations focus on two aspects – a personal reflection about how the camp impacted the camper and an assessment or evaluation of each component of RSMC. In the camp essay the students are asked to share their views about their background and describe their own personal growth and development over the summer. They are also asked to comment on how RSMC affected this growth. In the evaluation portion, campers are encouraged to state what elements of RSMC they liked and why as well as what aspects of the camp they did not like and why.

I consider camp evaluations and essays excellent data sources from the campers' past that help to establish a time-line of their views. The personal reflection section of the essay provides insight into how the campers described their personal growth and related it to their background. These reflections constitute stories that the campers were telling about themselves and offer a rich source to see how the campers' identities were developing through the camp experience at the time when they were adolescents. The comments about camp courses, problem sessions, study groups, and research projects in the evaluations provide information on the development of an individual camper's mathematical competence aspect of their MLI. For example, a camper's description of their courses and how they interact in study groups shed light on what are their ways of knowing mathematics i.e. do they learn by studying independently or through participating in mathematical discourse with their peers and counselors. Furthermore, the RSMC evaluation portion provides exactly the information I need to identify the characteristics that are valued by the campers and for what reasons.

c. *Correspondence*: These include any emails, letters, or thank you notes sent to the faculty members or RSMC staff by the campers attributing success in their professional lives to components of RSMC. Such correspondence proved to be a useful supporting data source for two of the participants in this study. It was useful for identifying the particular characteristics of RSMC that impacted the camper's MLI and their educational and/or career trajectory. Furthermore, these documents helped in exploring the construct of SC when the participant credited RSMC or some aspect of its components for any part of her success in pursuing STEM. These data helped establish how the access to and use

of embedded resources in RSMC enhanced a camper's chances of attaining better opportunities with respect to higher education/career.

### **Summary of data sources and relevance to research questions**

Below I describe for each of my research questions, the type of data that I collected and explain how collecting that particular data helped me answer my research questions. I then summarize this information in a table.

Research question 1: How do the women participants (1990 – 2008, from low SES and/or minority background) of an informal, university affiliated, summer math camp –RSMC envision its influence on their mathematics learning identity?

- a. According to the participants, what was the nature of their mathematics learning identity (1<sup>st</sup> P) at the time they started the program?
- b. What views did these participants hold in the past (as recorded in their past documents such as journals) and what views do these participants hold at present (as narrated in their recent interviews, correspondence, survey) about the influence of RSMC (i.e. its particular affordances) on development of their mathematics learning identity?

The construct of MLI is explored in terms of a collection of stories about the three aspects of MLI - (i) math competence (which includes conceptions of math and learning or ways of knowing), (ii) perceptions of self as learner of math (which includes self-confidence, viewing oneself as a potential creator of and an active participant in the field), and (iii) narratives of gender/ethnicity/class influencing one's learning and sense of belonging in the field of mathematics. These aspects of MLI are explored in terms of stories about the descriptions and comparisons of the learning environments of RSMC

and the participants' high school. The stories are about - participants' views about the type of mathematical competence (their personal epistemologies or ways of knowing and conceptions of what constituted the discipline of math), participants' positionings in the two learning environments, participants' relationships with others in the two learning environments and how they were viewed by others (parents, teachers at RSMC and high school, peers RSMC and high school) as students of mathematics, what they thought about themselves as learners of mathematics after each summer of attending RSMC, why did they keep returning to RSMC, how did these self-perceptions relate, if at all, with regards to their membership in a larger societal group such as gender, ethnicity, and class, and the impact according to the participants of various components/practices of RSMC on their MLI (1<sup>st</sup> P) trajectories. The most important of these stories will be the self-addressed stories of the participants,  ${}_A A_A$  since these are the stories that have a more significant impact on one's actions (Sfard & Prusak, 2005). Furthermore, I consider the self-told stories (in the context of learning mathematics)  ${}_A A_A$  to be significantly influenced by  ${}_A A_C$ ,  ${}_B A_A$ , and  ${}_B A_C$  as well as the collection of stories about members of a larger group centered on characteristics such as a race, ethnicity, nationality, class, or gender with which A identifies represented as  ${}_B G_A$ . However, I do not truly have access to  ${}_A A_A$ . Therefore, my access to study first-person MLI is limited to  ${}_A A_C$  (1<sup>st</sup> P identity) or more precisely  ${}_{\text{Participant}} \text{Participant}_{\text{Researcher}}$ . The stories they tell will provide a means of tracing their shifting mathematics learning identities as they draw upon various discourses to make sense of their *vision* of their experiences (Solomon, 2009).

The first portion of the question asks according to the participants what the nature of the students' MLI (1<sup>st</sup> P) was at the start of the camp. This requires gathering of data in

retrospect. The self-reported interviews and correspondence (now) primarily provided a collection of stories to establish the type of MLI trajectory campers started with. The second part of the question is looking for participants' views at two points in time about the influence as envisioned by the participants of RSMC (i.e. its various components and practices) on their MLI – *how was it co-constructed or developed through interaction with components of RSMC's environment, what components/practices of RSMC according to the participants were responsible for this development*. Therefore, their journals (then), camp evaluations and essays (then), correspondence (then and now), survey (now), and self-reported interviews (now) helped create a time-line of their views about the development of their MLI (1<sup>st</sup> P) trajectories. This data also helped identify the particular affordances of RSMC that according to the participants influenced their MLI construction process.

Research question 2: How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their higher education and/or career trajectory in STEM areas?

This question explores the relationship of RSMC to a set of decisions taken by the participants through the views of these participants about the contribution of RSMC to their educational/career related choices. The construct of SC is used to study the impact of RSMC on higher education and career trajectories of the participants. This construct is explored in terms of the resources available to and accessed by the participant through social networks (e.g. parents, relatives, friends, acquaintances, peers, teachers, mentors, and organizations) before and after being a member of RSMC towards her status attainment (education/career) goals. In the context of this study, I have used the definition

of social capital provided by Lin (1999) who defines it as resources accessed in social networks that depend upon human capital (self/parental education and experiences), initial positions (parental or prior occupational statuses) and one's social ties (e.g. kin, friends, acquaintances, colleagues, organizations). The construct is primarily explored through the stories narrated by the participant during interviews and recent correspondence sent to the camp director. In order to see the impact of RSMC on the participants' SC, I had to first establish the nature of their SC at the start of the camp. This required gathering of data in retrospect. Interviews with the participant and the recent survey were the primary sources of data to establish the nature of SC that the participant recalls she had before starting RSMC. The second part focused on participants' views at two points in time about the influence as envisioned by the participants of RSMC (i.e. its various components and practices) on their higher education and career trajectory – *how was it affected through interaction with components of RSMC's environment, what components/practices of RSMC according to the participants were responsible for this effect*. Again the interviews were the primary source to establish the stories that the participants told about the contribution of RSMC to their decision making in pursuing STEM related higher education/careers. Supporting data sources such as correspondence written to the camp director helped in determining, for one participant, the particular components of camp that she credited for her success in pursuing STEM related education/career. These data helped establish, according to the campers themselves, how access to and use of embedded resources in RSMC enhanced their chances of attaining better statuses with respect to higher education and career related decisions.

Research question 3: Which particular characteristics/practices of the RSMC program did these participants come to value, if any, that led to the above impact?

This question seeks to identify the characteristics and elements of RSMC's environment that are valued by its female participants from low SES and/or minority backgrounds. Multiple data sources such as camp evaluations, survey, interviews, journals, and correspondence was used in answering of this question. Gathering this data helped identify particular practices that the participants value and mention either in their "then" data (journals, evaluations, and essays) or in their "now" data (survey, interview, and correspondence).

The table below summarizes the data sources needed to answer each portion of the research questions that are described in above narrative.

Table 4  
*Summary of data sources with relevance to each research question*

Research Question	Data collected	Relevance
1a. According to the participants, what was the nature of their MLI at the time they started the program?	<ul style="list-style-type: none"> <li>- Journals</li> <li>- Interviews (participant)</li> </ul> <p>Sources (2)</p>	Interviews and journals helped establish the type of MLI campers started with.
1b. What views did these participants hold in the past and what views do these participants hold at present about the influence of RSMC (i.e. its particular affordances) on development of their MLI?	<ul style="list-style-type: none"> <li>- Documents (Journals, camp evaluations, essays, correspondence, survey)</li> <li>- Self-reported interviews</li> </ul> <p>Sources (6)</p>	Past and present data helped create a time-line of participants' views and helped identify the particular affordances of RSMC that influenced the MLI construction process.

Table 4 Continued

2. How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their higher education and/or career trajectory in STEM areas?	<ul style="list-style-type: none"> <li>- Documents (Journals, camp evaluations, essays, survey, correspondence)</li> <li>- Self-reported interviews</li> </ul> <p>Sources (6)</p>	Interviews helped establish (i) the participant's initial SC prior to RSMS and (ii) the contribution of RSMC to the participant's SC. Correspondence with the camp faculty, and in some cases journals, and camp essays also helped in noting the contribution of RSMC to the participant's SC.
3. Which particular characteristics/practices of the RSMC program did these participants come to value, if any, that led to the above impact?	<ul style="list-style-type: none"> <li>- Documents (Journals, camp evaluations, essays, survey, correspondence)</li> <li>- Self-reported interviews</li> </ul> <p>Sources (6)</p>	This data helped in identifying particular practices that the participants valued and mentioned either in their "then" data – journals, evaluations, essays, or in their "now" data – survey, correspondence, interviews.

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## Data Analysis

I employed the general techniques that are recommended by various authors Merriam (1988, 2009), Yin (2009), and Creswell (2013) when describing approaches to qualitative data analysis to assist me in this phase. However, the specific approaches (that pay attention to the linguistic features) used in the book entitled *Mathematical Literacy: Developing Identities of Inclusion* by Yvette Solomon (2009), the work of Sfard and Prusak (2005), and the identity resource model described by Nasir and Cooks (2009) served as the primary guide to my data analysis which depends upon paying close attention to the use of participants' discourse (whether written in journals/camp evaluations or described in the interviews). In order to operationalize my theoretical perspective, I made use of Nasir and Cooks' (2009) identity resource model. When analyzing the impact of RSMC on participants' MLI and SC, I classified their utterances from different data sources into the three identity resources – material, relational, and/or

ideational. I then illustrated that these three core identity resources as described in Nasir and Cooks (2009) were made available by RSMC (through its various components and practices) and taken up by the participants as they recalled their past experiences at the camp. The availability of and the value of these resources came from the participants themselves. I then showed how the participants' MLI prior to coming to RSMC was interrupted and shifted on a different trajectory through the interaction of the participants with the practices of RSMC in the context of learning mathematics. I also showed how particularly relational resources offered at RSMC enhanced the participants' SC thereby impacting the decisions they took regarding their higher education/career choices.

The figure below summarizes the general steps recommended by Creswell (2013) that I followed during analysis of my data:

<b>Data organization</b>	Create and organize files for data for each participant
<b>Reading, memoing</b>	Read through each data source collected, make margin notes, write memos, form initial codes
<b>Describing the data into codes and themes</b>	Describe each embedded case and its context
<b>Classifying the data into codes and themes</b>	Use category aggregation to establish themes
<b>Interpreting the data</b>	Theorize themes, use direct interpretation of what was learned from each case and across cases
<b>Representing, visualizing the data</b>	Present in-depth picture of the embedded cases in relation to the main case using narrative, tables, and figures

*Figure 7.* Creswell's 2013 qualitative data analysis general steps

For each of my research questions, I describe below how the type of data collected was analyzed for each of my constructs. I then summarize this information in a table. The first step however was organizing the data for each of the research questions before the analysis began.

Research question 1: How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their MLI?

The following figures parse different parts of MLI - mathematical competence, perceptions of self as a learner of math, and narratives of gender/race/class into more specific aspects that I explored in the data. Some of these aspects are informed by the works of Boaler and Greeno (2000), Solomon (2009), Nasir and Cooks (2009), and Nasir et al. (2012).

According to the former female participants of RSMC, what was the nature of their MLI at the time they started the program?		
Descriptions of Math classroom (CR) environments in high-school or middle school (HS/MS)	Positioning/role within Math CR environments in HS/MS	Perceptions about definition of math and learning/doing math before RSMC
Perceptions of self as a learner of math before RSMC	Narratives of gender/race/class before RSMC	Relationships with others (teachers, peers) and experiences of teaching styles before RSMC

*Figure 8. Color-coding the data for Pre-MLI*

What views did the participants hold in the past and what views do these participants hold at present about the influence of RSMC (i.e. its particular affordances) on development of their MLI?		
Descriptions of Math learning environment at RSMC (study groups, problem sessions etc.)	Positioning/role within Math learning environment at RSMC	Perceptions about definition of math and learning/doing math after RSMC
Perceptions of self as a learner of math during/after RSMC	Relationships with others (camp faculty, counselors, peers) and experiences of teaching styles	Narratives of gender/race/class during/after RSMC
Perceptions about the impact of RSMC on development of MLI trajectories (now in retrospect)	Stories about the components of RSMC that are perceived to have impacted development of MLI trajectories (now in retrospect)	

*Figure 9. Color-coding the data for Post-MLI*

Similar to the work of Solomon (2009), in the interviews and other data sources I explored the learning environments of the participants through their own accounts of the discourses of mathematics learning that constituted the practices of these environments. Here the uniqueness and typicality of a community of practice was central to the investigation of the learning of mathematics (Solomon, 2009). Considering the ecological perspective framework, I explored the first person mathematics learning identity development through the participants' own accounts of how they positioned themselves and were positioned within different learning environments by the unique practices and components of these communities, and the different ways of being that these communities afforded (Boaler & Greeno, 2000; Solomon, 2009). I classified the practices of RSMC into three core identity resources that were made available to the participants using Nasir and Cooks' (2009) description of the identity resource model. At the same time we must not forget that what students experience in different learning environments will always be colored by the stories they tell because as Sfard and Prusak (2005) note "...it is our *vision* of our own or other people's experiences, not the experiences as such, that constitutes identities...our narrative definition presents them as *discursive counterparts* of one's lived experiences" (p. 17).

My analysis of the journals, camp evaluations, essays, survey, correspondence, and interview transcripts involved literal reading and re-reading of these data sources and writing analytic memos. Even though guided by the aspects of participants' MLI and their vision of RSMC's impact on it as noted in the figures above, I remained open to the codes that emerged from the data. I divided the data sources into two time-points – Past (journals, camp evaluations, essays, correspondence) and Present (interviews, survey,

correspondence). During this perusal I paid close attention to the use of particular words and language (Solomon, 2009). For example in order to determine the nature of participants' MLI prior to RSMC or Pre-MLI, I looked in both Past and Present data sources for utterances or codes such as *learning math meant memorizing formulas and procedures, I thought being good at math meant being fast, I was really good at math, I would try to prove procedures before using them, I learned best in a group, being good at math is a white trait, I was an exception, I was good at math even though I am Hispanic* etc. I looked for similar utterances as well as utterances that indicated a shift in views about learning, math, or self as a learner when the participants described the learning environment of RSMC and what it meant for them to learn math in this new community. From these observed utterances I generated categories (combining codes) such as *beliefs about learning math pre/post RSMC, definitions of math pre/post RSMC, self-perceptions as a learner based on conceptions about being good at math pre/post RSMC, narratives of gender/race/class in the context of learning pre/post RSMC, and practices of the environment impacting MLI (material, relational, ideational)*. These categories were then used to make comparisons between the math learning environments of RSMC and the participants' high-school/middle-school. Once the categories were created and comparisons made I linked them together to see what themes emerged within each case. This step involved going back to the case data base for each participant and re-organizing data into a visual representation such as charts and tables so that the relationships among different sets of data could be better deduced, leading to observing a common theme. I used my analytic lens (ecological perspective) framework and literature such as *ways of knowing* (epistemologies of mathematics) as described by Becker (1995) or racial

storylines and their implications for learning as discussed by Nasir et al. (2012) to theorize my themes.

### **Pilot data analysis illustration**

The above explanation may be better understood through an example that illustrates the process described above at least in part. I conducted a pilot interview with one former female participant of RSMC who attended the camp during the years of 1998, 1999, and 2000 in order to help me refine my interview questions. In this interview I only focused on the mathematical competence aspect of my construct MLI although some of the data may also apply to perceptions of self as a learner aspect of MLI. Since I conducted this interview in April 2014 as a trial, therefore the references of “ability” in the transcript really mean competence. Also, multi-part questions were used in the interview, which after the trial I quickly learned was not a good idea because the participant would forget to answer all the parts. I conducted similar trial interviews with this participant to inform and refine the development of my interview questions for each of the research questions. I will use part of the transcript below to illustrate how the analysis worked. In the following excerpt the participant, we shall call her Spencer, is responding to questions about the level of her mathematics competence and her understanding of what learning or doing math meant before RSMC. In this script S=Spencer and I=interviewer.

**S:** Well I was good at ...er...math ...er...I could always get the answer when they gave it to me. But I was very disorganized...er...and very like get the answer just get the answer...er..kind of oriented. I remember that I turned in my first homework assignment, my first assignment at math camp on a piece of like sketch paper ...very disorganized with just ..er..very disorganized with just with the answers boxed because somehow I thought that would be enough [laughs]  
**I:** [laughs] uh-huh

S: and yeah I quickly learned that yeah that was not good enough. Yeah because before that was the level I was expected to perform at so like solve problems and put boxes around the answers and then that's it and nothing else mattered except the boxes around the answers.

I: uh-huh... Think back to the time prior to joining the Riverside Summer Math Camp, now describe what you thought "learning" or "doing" mathematics meant or entailed? What did you think your role was in learning mathematics? And this is before you came to the math camp.

S: Right. Well, before I came to math camp [papers ruffling wind sound] I took Algebra I in 7<sup>th</sup> grade and Algebra II in 8<sup>th</sup> grade and for the most part it was figuring out, well in Algebra I guess it was what  $x$  was you know and learning the processes well enough to apply them to solve the problems... umm... I do remember one time on my own when I was learning, when we were learning about absolute value I didn't understand why the ...um... the... um... I forget something about how ...um... the absolute values of two numbers negative numbers reversed their order in the less than like if you have  $x < y < 0$ , then the  $|x| > |y|$ . So I wrote kinda out like a very neat explanation because I thought that I just had an epiphany.

I: um-huh... right

S: And so that's like kinda one moment of doing the first proof I ever wrote. I kinda did that of my own initiative but that wasn't normally expected of me and that wasn't an assignment and like I said normally it's just...er... cleverly apply the methods, not that we didn't do hard problems, we did hard problems but they were all just like ...er... it was kind of figure out what  $x$  is somehow [laughs]

I: [laughs] uh-huh.

S: And so that was my understanding, figure out what  $x$  is and put a box around it.  
(Lines 26 – 53; Interview with Spencer)

The phrases in the script above are coded based on the color codes listed in Figure 8. In this fashion I continued to color code the script. When coding the handwritten documents such as journals I just highlighted the pertinent phrases, made notes in the margin, and assigned a code. When new codes emerged that did not fit into the ones described in Figures 8 and 9 then they were coded by highlighting and summarized using a short phrase that captured their purport. Phrases above as well as ones that follow in the whole interview under the *Perceptions about learning/doing math before RSMC*, some from the *Descriptions of Math classroom environments in high-school or middle school*, and some from the *Positioning/role within Math CR environments in HS/MS* codes that

might relate to the aspect of learning/doing math before RSMC were grouped together under one category in a table or a column to see what they suggested about the practices of the learning setting:

<i>Perceptions about learning/doing math before RSMC</i>	<i>Participant's utterances</i>		
Getting the answer and putting a box around it	<i>"very like get the answer just get the answer..er..kind of oriented"</i>	<i>"just with the answers boxed because somehow I thought that would be enough"</i>	<i>"so like solve problems and put boxes around the answers and then that's it and nothing else mattered except the boxes around the answers."</i>
Learning procedures	<i>"learning the processes well enough to apply them to solve the problems"</i>	<i>"like I said normally it's just..er..cleverly apply the methods"</i>	
Figuring out what $x$ is	<i>"that was my understanding, figure out what <math>x</math> is and put a box around it."</i>	<i>"for the most part it was figuring out, well in Algebra I guess it was what <math>x</math> was you know"</i>	
Memorizing properties	<i>"I think we might have learned about the what the commutative property was like memorized it but we certainly didn't use it to prove anything" (Lines 102 – 103)</i>		
Teacher justifies methods (not me)	<i>"like we never would cite like this is true because ... like step by step citing it. And that would be something that the teacher did like justify this method instead of something that I did" (Lines 104 – 105)</i>		
<b>Emerging theme</b>	Memorizing procedures (justified by the teacher) and cleverly applying them to find the right answer and boxing it.		

Figure 10. Spencer's perceptions about learning/doing math before RSMC

The patterns of similarity and frequency from the interview regarding the beliefs of Spencer about learning or doing mathematics before starting RSMC lead me to conclude that for the participant in this interview mathematical competency (learning or doing math) before starting RSMC meant memorizing procedures (justified by the teacher) and cleverly applying them to find the right answer and boxing it. What type of a *way of knowing* does this suggest for Spencer before RSMC in terms of the personal epistemologies described by Becker (1995)? We can see that even though Spencer one time had the tendency to explore math ideas out of her own initiative as reported by her when she tried to understand if  $x < y < 0$  implies  $|x| > |y|$ , she primarily fits the category of a received knower (*Individual considers her knowledge to be given to her from an authority. She memorizes then mimics/repeats the words of the authority without questioning or understanding the knowledge of the authority*) before coming to RSMC. We may look at the same pilot interview transcript with Spencer as an example to see what it may tell us about her perceptions of self as a learner of mathematics aspect of MLI. Statements such as “Well I was good at ...er...math ...er...I could always get the answer when they gave it to me” and “Well, before I came to math camp [papers ruffling wind sound] I took Algebra I in 7<sup>th</sup> grade and Algebra II in 8<sup>th</sup> grade” suggest that Spencer viewed herself as being good at math. Her mentioning to me that she took Algebra in middle-school (which is not normally the case as most students in US take Algebra in high school) suggests that Spencer seemed to have a positive attitude about her proficiency in math. But what counted as success and being good at math in her middle school learning environment is revealed in her conception of learning/doing math - memorizing procedures, getting the answer, and boxing it. Furthermore, statements such

as “before that was the level I was expected to perform at so like solve problems and put boxes around the answers and then that’s it and nothing else mattered except the boxes around the answers.”, “like we never would cite like this is true because ... like step by step citing it. And that would be something that the teacher did like justify this method instead of something that I did” reveal her positioning in her Algebra classroom in the role of a received knower and her development of identities that are compatible with a procedure-driven figured world (Boaler and Greeno, 2000). However, when this conception is shaken during her first year at RSMC she describes herself as being disorganized and answer centered. Therefore, in her new learning environment of RSMC, Spencer quickly learns that just turning in answers [without any work] is not enough. So, her perceptions about herself being good at math in her middle school may differ in her new math camp. However, more probing is needed about her first year math camp experience to understand what sort of a change in perceptions about her math competence Spencer experienced and how her mathematics learning identity trajectory changed. Her stories of her first year experience at math camp would reveal whether she shuts down developing an identity of marginalization or whether she started seeing herself as a legitimate participant – as a novice on an inward trajectory with the potential to make constructive connections in mathematics (Solomon, 2009).

The above example shows in part how the analysis for the construct of MLI proceeded in order to answer Research question 1. I repeatedly explored the categories and linked them to discover the emergent themes. I also did a cross-case comparison to look patterns of similarities and differences in the views of the participants by using a visual tool like a table or chart such as the one below:

	Participant 1	Participant 2	Participant 3	Participant 4
MLI pre RSMC				
MLI during/post RSMC				

*Figure 11.* Template for participants' cross-case comparison for MLI

Research question 2: How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their higher education and/or career trajectory in STEM areas?

I explored the above question through the construct of SC. In order to see if RSMC had any impact on the participants' decision making about their future career/education thereby by shifting their higher education/career trajectories, I had to first establish the nature of their SC and the plans they had for their future before coming to RSMC. The following figures parse different parts of the above question into more specific aspects that I explored in the data.

According to the former female participants of RSMC, what was the nature/level of their SC at the time they started the program?		
Descriptions of pre RSMC higher educational/career aspirations	Resources in the social network (family members, peers, teachers etc.) who may have helped shape the future aspirations	Descriptions of any plans the participants' had made about their future careers or higher education to realize their aspirations.

*Figure 12.* Color-coding the data for pre-SC

What views did these participants hold in the past and what views do these participants hold at present about the impact of RSMC (i.e. its particular affordances) on their SC thereby impacting their decisions with respect to their future plans about higher education/careers?		
Descriptions of during/post RSMC career/educational aspirations	Resources in the social network of RSMC (faculty, counselors, staff, peers) who helped shape these aspirations	Participant accounts of the role that RSMC played, if any, in their actual education/career choice [resources that were made available]
Perceptions about the change in SC if experienced at all in the past or at present in hindsight	Perceptions about the impact of RSMC on SC and shaping the higher education/career trajectory [descriptions of components responsible for the impact] (now in retrospect)	Descriptions of RSMC's role in impacting the decisions that were taken about applying colleges, choosing a major etc. (from past or present data sources)

Figure 13. Color-coding the data for post-SC

Interviews with the participants were the primary source of data to establish the nature of SC that the participants recalled they had before starting RSMC and to establish the stories that the participants tell about the contribution of RSMC to their SC. Survey, correspondence with camp faculty/staff, journals or camp evaluations served as a secondary data source to find instances where the participants credited the camp for their success in pursuing STEM related education/careers. However, the interview, survey, and correspondence data proved most useful in establishing the stories that the participants told about the contribution of RSMC to their decision making in pursuing STEM related higher education/careers. I read through the past and present data sources to identify narratives guided by the aspects identified in the figures above or what came from the data that contributed to the understanding of SC. For example, I looked for utterances such as *I never thought I would end up at a university like Harvard, but my faculty at camp gave me the confidence to apply, my camp faculty wrote recommendation letters for*

*me that improved my chances to go to a good school, I made great connections with some of my counselors in good schools and they helped me with my application process to go to college, I never had a role model in math or science until I came to RSMC, both my parents are well connected so RSMC really didn't help me in that way, I was inspired by the camp faculty so I decided to become a math teacher myself, RSMC significantly improved my math knowledge and skills as a result I became confident in pursuing a career in computer science and math, I always planned on pursuing a career in a STEM area, RSMC had no impact on any of my decisions about by higher education or career plans* etc. The process of analysis proceeded in a similar way as mentioned earlier with assigning codes to the words/phrases, then combining codes that go together to form categories, and then linking categories together to reveal the themes. This step was followed by a cross-case analysis to find common themes or differences among all 4 cases. The rest of analysis process proceeded in a similar way as described for the constructs above. I also made use of Nasir and Cooks' (2009) identity resource model when analyzing the data for SC. In particular, I identified relational resources that significantly impacted the participants' SC at RSMC. For example, a camper may have access to people in RSMC with varying degree of SC, but how the camper recognizes this and mobilizes this capital towards her status attainment (education/career – achieved status) goals depends on the interaction between the camper and the person whose SC the camper would like to utilize. Furthermore, it also depends on the person who may offer this capital to the camper without the camper requesting it through this process of interaction. Here the relationships that the campers form with others at camp play a central role in understanding how the construct of SC is impacted. This data primarily

came from the narratives of the campers. The figure below shows how the codes as described above fit into different categories:

RSMC had no impact on my aspiration to pursue STEM, but helped me make important decisions to realize my dream	Supporting participant narratives
RSMC significantly improved my math knowledge and understanding of math	Supporting participant narratives
RSMC gave me role models to follow in STEM areas	Supporting participant narratives
RSMC inspired in me a love of math and computer science	Supporting participant narratives
...	...

*Figure 14.* Template of categories and supporting narratives for SC

Research question 3: Which particular characteristics/practices of the RSMC

program did these participants come to value, if any, that led to the above impact?

Past and present data sources for answering this question include camp evaluations, journals, correspondence, survey, and interviews. Gathering this data helped in finding out particular practices that the participants value and mention either in their “then” data (journals and evaluations) or in their “now” data (correspondence, survey, and interview). A list of a priori codes was developed through conversations with RSMC faculty and staff such as *Weekend trips (with peers, counselors, and faculty)*, *Study groups*, *Problem sessions*, *enthusiasm of camp faculty*, *no exams* etc. However, I remained open to any codes that came from the data. I divided the data sources into two time-points – Past (journals and camp evaluations) and Present (interviews, correspondence, and survey). I read through Past and Present data sources making a note of the characteristics/practices valued by each participant in a table. I then compared these valued practices across all four participants and identified common practices. A note was made in the analysis report

about the practices that were identified by all four participants. Differences in the practices valued from Past and Present data sources were noted. I also described the improvements that were mentioned by one of the participants to make the RSMC experience even better.

The final step in the data analysis process for each of research questions involved drawing conclusions and verifying the conclusions as well as data quality by the process of triangulation across multiple data sources and by using multiple investigators such as my committee members. I met with my committee chairs on regular basis as well as requested the feedback of other committee members on my findings, each of the case-reports I was preparing, and my cross-case analysis.

#### **Summary of the data analysis process and its link to the theoretical framework**

I summarize in the table below for each of my research questions, how the data was analyzed and briefly describe how the data and its analysis are linked to my framework.

Research Question	How data was analyzed?	What's the link to the theoretical framework?
<p>1a. According to the participants, what was the nature of their MLI at the time they started the program?</p> <p>1b. What views did these participants hold in the past and what views do these participants hold at present about the influence of RSMC (i.e. its particular affordances) on development of their MLI?</p>	<p>Data was viewed as a <b>collection of stories</b> about camper's MLI. Data was analyzed based on the steps outlined in Figure 7.</p> <p>Process of coding although guided by codes developed in literature (Becker, 1995; Boaler &amp; Greeno, 2000; Solomon, 2009; Nasir &amp; Cooks, 2009; Nasir et al., 2012) also remained open to what came from the data. Following an iterative process, codes were collapsed, categories generated, and themes developed.</p>	<p>MLI of campers is co-constructed and progresses through the interaction between the camper (what she brings to the interaction) and the resources and opportunities afforded to the camper (<i>effectivities</i>) by the environment (RSMC) as a result of this interaction.</p> <p>The data (then and now) helped establish the type of MLI the camper thinks she started with and helped describe any shifts in the MLI campers think they developed through interacting with various <b>components of RSMC</b>— <b>people</b>, <b>curriculum</b>, and <b>structure</b>.</p> <p>The identity resources offered to campers were classified as material, relational, and ideational (Nasir &amp; Cooks, 2009). The stories from the participants helped develop a time line and pinpoint the contribution of RSMC as envisioned by the participants themselves to the development of their MLI.</p>
2. How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their higher education and/or career trajectory in STEM areas?	Codes from literature as described in Lin (1999) were extracted and used to guide the analysis. However, I remained open to any codes that came from the data.	SC maybe co-produced or affected through the interaction between the camper (what she brings to the interaction) and the components of the environment (RSMC – <b>people</b> , <b>curriculum</b> , <b>structure</b> ). This rendering as described by the camper was analyzed. In particular the impact of relational resources (Nasir & Cooks, 2009) on participants' decision making process to pursue STEM at top-ranked institutions of higher education was highlighted.
3. Which particular characteristics/practices of the RSMC program did these participants come to value, if any, that led to the above impact?	A list of a priori codes was developed through conversations with RSMC faculty and staff. However, I remained open to any codes that came from the data.	Identifying affordances of an environment from the perspective of a particular group of its members.

Figure 15. Summary of the data analysis process and its link to the theoretical framework

## **Trustworthiness**

I addressed the concept of *trustworthiness* in my research through addressing the concerns for reliability and ethics as described by Merriam (2009). I tried to ensure reliability for my study by checking the extent to which my findings are consistent across the data sources and credible (through seeking advice from my committee members and clarifying biases). I verified my findings through triangulation across multiple data sources described in this study in order to increase the credibility and trustworthiness of my research. I followed the guidelines described by Merriam (2009) to conduct my study in an ethical manner. Furthermore, as a qualitative researcher I need to acknowledge my own assumptions and biases so that I can be wary of them not only during the analysis and interpretation phase but also throughout the process of conducting research thereby contributing to building the credibility and trustworthiness of my study.

#### **IV. FINDINGS: CASE REPORTS**

The purpose of this study is to describe in my words the stories of the participants from economically disadvantaged and/or minority backgrounds who attended a university affiliated informal mathematics summer camp program – RSMC during their high school years, in particular about (a) how RSMC affected their mathematics learning identity; (b) how RSMC influenced their educational and career trajectories, if at all; and (c) what particular characteristics or practices of this program did the participants come to value, if any.

This study employs a single-site embedded case study design where RSMC (the learning environment) forms the main unit of analysis and its female participants from diverse backgrounds constitute the embedded units of analysis. As described in Chapter II, the ecological and situative perspective informs my analytic lens for this study. There are three aspects through which I study the development and shifts of MLI among the participants in this study in two different learning environments. These aspects are – (i) beliefs about mathematics as a discipline and what entails learning or doing math, (ii) perceptions of self as a learner of math, and (iii) narratives of race, ethnicity, gender, national origin, or class influencing beliefs about one’s ability to learn math. I will illustrate how constraints and affordances of a given learning environment induce a certain behavior and influence the beliefs about the aforementioned aspects among students as well as how students come to measure success in a learning space. I will also show how challenges and support structures within a learning environment to persist through the challenges are essential in creating opportunities through which students’

change or shift their MLI trajectories. I do not generalize my findings here, but will show in chapter 5 how my findings fit into a larger body of literature on identities. The impact of RSMC on higher education/career trajectories of the participant is studied through the construct of social capital (SC).

I analyzed my data to answer my research questions using my analytic lens, the identity-resources framework (Nasir & Cooks, 2009), and the works of Becker (1995), Boaler and Greeno (2000), Solomon (2009), Nasir et al. (2012), and Lin (1999).

Interviews with the participants constitute one of my primary data sources for each of my research questions. The documents that constitute supporting data sources for this study include participant journals, camp evaluations, essays, correspondence with RSMC faculty and myself, and a recent survey. In this chapter I describe the findings of my study through four embedded-case reports followed by a cross-case analysis. The case reports are grouped by two participants who graduated with an undergraduate degree in a STEM area upon leaving RSMC and two participants who started out as STEM majors in college but later switched to a non-STEM field owing to a negative experience in the college environment.

Each case report is divided into three sections: MLI co-construction and shifts, Higher Education Trajectory upon leaving RSMC, and RSMC characteristics/practices valued by the participant. The three sections in each embedded-case correspond to the three research questions:

1. How do the women participants (1990 – 2008, from low SES and/or minority background) of an informal, university affiliated, summer math camp –RSMC envision its influence on their mathematics learning identity?

- a. According to the participants, what was the nature of their mathematics learning identity (1<sup>st</sup> P) at the time they started the program?
  - b. What views did these participants hold in the past (as recorded in their past documents such as journals) and what views do these participants hold at present (as narrated in their recent interviews, correspondence, survey) about the influence of RSMC (i.e. its particular affordances) on development of their mathematics learning identity?
2. How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their higher education and/or career trajectory in STEM areas?
  3. Which particular characteristics/practices of the RSMC program did these participants come to value, if any, that led to the above impact?

The findings from and implications of this study also help establish a model for investigating the role of summer math camps in creating a learning space where young women from diverse backgrounds feel empowered. The model is established through describing and discussing the stories of these women about the impact of such a camp on their learning identities and educational/career trajectories.

I will introduce the pseudonyms for some of the RSMC faculty and guest speakers below, as I will be referring to them frequently in the case-reports:

Dr. Mark Weitzman – is the founder and director of RSMC. He also teaches the Number Theory course at camp. He is primarily responsible for all aspects of RSMC. Campers and counselors at RSMC address their journals to him and he is responsible for reading

and responding to the journal entries every week. He is also a professor of mathematics at the university with which RSMC is affiliated.

Dr. Tony Hill – teaches the Analysis course at RSMC and is also a professor of mathematics at the affiliated university.

Dr. Edmund Martin – teaches Combinatorics at RSMC and is a professor of mathematics at the affiliated university.

Drs. Dan and Nora Woods – teach the Mathematica course at RSMC. They are retired math professors from the university at which RSMC is housed.

Dr. Delores Fernandez – is often a guest speaker at the RSMC colloquiums. Her field of expertise is Graph Theory and she is an associate professor of mathematics.

Harriet – is a famous American author, columnist, and mathematics major. She is often invited as a guest speaker at the RSMC colloquiums.

### **Case 1: Anahi**

I first met Anahi over Skype for our first interview. Although we had corresponded over the email a few times prior to that, this was the first time I put a face to her name. Anahi is a petite Hispanic woman in her late twenties, with a confident personality. Anahi grew up in an urban area that was predominantly Hispanic from working class families. Her father was a construction worker and her mother a homemaker. Both her parents only speak Spanish. She is a first generation college student in her family. She graduated as an engineering major from a top-ranked University in U.S. For the purposes of this study we shall call this school University A. She worked in the field for five years as an associate design engineer, structural engineer,

and then as a senior project engineer at successful firms such as Foster Wheeler, Inc. Anahi is currently pursuing her MBA at another highly ranked university.

### **Trajectories of identities: MLI co-construction and shifts**

In this section I will describe the story of Anahi, a young Hispanic Engineer, and her experiences at an informal math summer program - RSMC during her high school and undergraduate years. In order to determine the identity trajectory that RSMC helped create for Anahi, I will first explore the path she was already on prior to coming to RSMC. This will entail describing her perceptions about math as a subject, learning math, and herself as a learner of math in her high-school classrooms. Next I will describe the shift in the MLI trajectory that RSMC helped create for Anahi.

### **Pre-MLI: What constitutes learning in Math?**

In order to determine the impact of RSMC on Anahi's MLI, I asked her to recall her beliefs about learning and doing math prior to coming to camp as well as describe her perceptions of herself as a student of mathematics. We shall call this Anahi's Pre-MLI. The two retrospective interviews are the primary data source for determining her Pre-MLI.

The following figure shows an example of utterances from her interviews that lead me to conclude that for Anahi prior to RSMC learning math meant memorizing what the teacher said and being able to regurgitate it during exams, while doing math meant being able to quickly solve problems that always had one exact answer. Math itself was seen by her as something that was just a bunch of numbers with no real applications.

<i>Perceptions about learning/doing math before RSMC</i>	<i>Participants' utterances</i>		
Getting the one right answer quickly. The answer was more important than the process.	"Doing math meant being able to solve a problem with numbers that always had <b>one exact answer</b> "	"it was all about getting a <b>quick answer</b> "	"Finding a <b>shortcut</b> and <b>getting to a specific number</b> . It's all about the number, <b>never about</b> this is who <b>created this concept</b> , ...and developed it... and <b>why we use it now</b> "
Learning procedures by memorizing for exams and solving problems	"Figuring out how to <b>memorize teacher's procedures</b> and being able to <b>regurgitate</b> it during exams"		
Math is a bunch of numbers or equations with one exact answer and no practical application.	"division... multiplication, um, or it was <b>just numbers</b> ... some <b>algebraic equations</b> that always had a, a <b>direct answer</b> "	"You rearrange the <b>numbers</b> and you get <b>an answer</b> ... that was all that I had concept of Math"	"Not too many people cared about learning it as they saw <b>no practical application</b> "
Teacher justifies methods (not me)	"The <b>teacher would</b> give a <b>lecture</b> , then an <b>example</b> , then another example"		
<b>Emerging theme</b>	Memorizing procedures (justified by the teacher) and regurgitating them during exams to find the right answer. Math itself is just a bunch of numbers or equations with one exact answer and no practical application.		

Figure 16. Anahi's perceptions about learning/doing math before RSMC

### **Pre-MLI: Am I good at math? (Self-perceptions about being a learner of mathematics)**

When I asked Anahi to describe her self-perceptions as a student of mathematics prior to RSMC, she said she considered herself an excellent student. This perception was based on her grades and the discourses about being "good" at math that Anahi felt were

prevalent at her school. These discourses equated competence with memorization of procedures, speed, and high scores on tests. The students who were considered “good” at math always did what the teacher said, tended to work alone and tried to maintain top rank in class. Anahi also recalled that the level of math at her high school was not very challenging. Teachers generally had low expectations of students and usually skipped all the challenging material from the text. Most of the students themselves didn’t really care about math and saw no practical application for it. This meant being “good” at math was not hard at all as meeting these expectations of teachers was easy enough and maintaining the top rank among her unmotivated peers was just as easy for Anahi. The figure below shows the practices of Anahi’s high school learning environment, the behavior that they developed in her, and how she came to measure her success in such a community. These findings are supported by Anahi’s quotes from her two interviews.

Participant utterances	Characteristics/Practices of the Learning environment	Behavior developed	Measuring success given for the behavior
<p>“The teacher would give a lecture, then an example, then another example”</p> <p>“To sit, listen, and answer the questions correctly”</p>	Listen to the teacher and solve the problems given by the teacher correctly.	To sit, listen to the teacher, and answer questions correctly.	Finding/ getting the right answer and obedience
<p>“you compete against each other... And whoever gets the first answer, it's kinda the, the winner.” “it was all about getting a quick answer” “Finding a shortcut and getting to a specific number”</p>	Competing against your peers, solving questions quickly to be the winner.	Solve the problems that are given to you quickly.	Being the highest ranked/best student in class
<p>“they couldn't be pushed too much because the students couldn't strive to those levels..... and they would probably wouldn't graduate many students if they keeping up the bar.”; “for me it was, um, you ... if they tell me that I need to solve three problems, I'll solve the three problems and won't do anymore”; “Not too many people cared about learning it as they saw no practical application.”; “You're the best student we've ever had...I'm like, "Oh great. Wonderful. It doesn't take much to be the great student then."</p>	<p>Having low expectations of the students</p> <p>Curriculum that is not very challenging.</p> <p>Unmotivated peers.</p>	<p>Doing the bare minimum</p> <p>Meeting the low expectations of the teachers and thinking that it doesn't take much to be good at math.</p>	<p>Doing what was assigned in the given time frame.</p> <p>Teacher's praise</p>
<p>“Group work was not a big part of school. Peers don't share their knowledge because they want to get a better grade.” “No presentations, no extra questions, no requirement to work with others.”</p>	Working individually in a competitive environment.	Working alone on homework.	Getting good grades.
<p>“Learning meant memorizing what the professor said and being able to regurgitate it during exams”</p> <p>“As a student you just had to prove on the exam you knew how to answer the problem.”</p>	Memorizing what the teacher said; regurgitate it during exams	Memorize teacher's procedures and be able to regurgitate it during exams	Getting good grades on the exams
<p>“since I was a valedictorian [inaudible 00:17:43] in my class... I set the speed for everyone else”; “I paid attention in class ... so I always tried doing all the bonus questions”</p>	Good at math means being a valedictorian and ahead of all the peers	Paying attention in class and solving all the bonus problems meant success	Getting the right answer/good grades
<p><b>MLI (<math>A_A/A_C</math>) being developed:</b> (math competence and self-perceptions as a learner aspects of MLI)</p>	<p><i>I am good at math because I am a valedictorian, get better grades than my peers by paying attention in class, memorizing, and doing what is expected of me. I am good at completing the assigned problems quickly, getting the right answer, and successfully following my teachers' directions. Being the best in math isn't very hard.</i></p>		

Figure 17. Anahi's MLI (self-perceptions as a learner) before RSMC

The data suggests that Anahi developed a learning identity to succeed in the practices that were valued by her high school learning environment. These practices as noted above seem to equate proficiency in math with memorizing procedures, speed, and high test-scores.

### **Pre-MLI: Subscribing to racial, class, and/or gender ‘storylines’ in the context of learning math**

The following remarks about gender, class or ethnicity during our interview portion of pre-MLI lead me to conclude that Anahi was trying to say that she is good at math despite all the gender, class, and ethnicity constraints of her situation. Therefore, she must be an exception to what is considered the norm within her community.

Narratives of gender/ethnicity/class
“I was different in various forms – Hispanic race, female minority, and my parents were low income family... In my school almost every student fit the same profile I did”
“I come from a Hispanic family and both my parents only speak Spanish”
“So, and my school, since it's one of those school in one of kind an under [represented 00:10:59] in bad regions in [...], it's not terrible but the school didn't have, doesn't have many resources”
<b>Emerging Theme [MLI (AA/AC) being developed</b> (narratives of gender/race/class aspect of MLI): <i>I am good at math despite being a Hispanic female from a low income family who attended a high school for the underprivileged. I am different from the norm, so I must be an exception.</i>

Figure 18. Anahi’s MLI (narratives of gender/ethnicity/class) before RSMC

### **Post-MLI: After the culture shock: moving onwards and upwards**

The findings in this section illustrate how RSMC help create an inbound STEM identity trajectory for Anahi by affording her material, relational, and ideational identity resources (Nasir & Cooks, 2009) throughout her stay. I will show how over the course of her affiliation with RSMC, Anahi became more connected to the practice of Mathematics

and developed a broader and holistic learning identity in the context of math in particular and STEM in general. Anahi's retrospective accounts in two interviews and her handwritten documents (e.g. journals, camp essays, and camp evaluations) from when she was a camper and counselor at RSMC are used as data sources to help tell her story. In her camp essay and evaluation, Anahi described RSMC as a unique and novel experience. For example, she wrote in her camp essay from 2001 "This camp has been a great new experience for me...In this camp problems are worked out from a different perspective." During our first interview she recalls that it was the first time she had stayed away from home for a long period of six weeks in dorms at a college campus. Her parents, although hesitantly at first, gave her permission to attend RSMC thinking that a math camp could pose no grave danger to their daughter.

### **First year at RSMC - challenges and struggles**

The script below from my first interview with Anahi illustrates the challenges Anahi faced during her first year at camp. The script further shows that it was in the overcoming of the challenges that Anahi faced during camp that led her to shift her perspective on mathematics and learning.

- Anahi: Um, then when it came down to the studying, the camp kicks you off with [Mark] introducing you to Number Theory, which is something that my school would have never teach and I only ever saw it mentioned when I went to college.
- Anahi: So it's something like I, I didn't even know what Number Theory meant.
- Anahi: This is number ... It was, it was a confusing concept to me.
- Anahi: So when we started going through the first class, I was lost.
- Anahi: Completely lost.
- Anahi: Usually it's I give you Math problem and you give me an answer and this is the answer.
- Anahi: But this is i asked you a general question and you come with the steps to get to that process.
- Anahi: Think-this is kinda like, uh, mixing English essays where you have to drive at certain things,

Anahi: ... and then at the end, still having this mathematical equation at the end.  
Anahi: Um, the whole concept was completely new to me.  
Anahi: And so, um, in my group I instantly noticed that there were some people who had, already had Number Theory before.  
Anahi: It wasn't the first they're exposed to it. They had quickly got down to the numbers and learn the process and started answering stuff on the board. I'm like I don't even know how to contribute. This is something that is completely strange to me.

From the script above we may note that during the first year at camp Anahi felt lost, confused, and intimidated. The material in her Number Theory course was something she had never seen before. Furthermore, working with problems that may or may not lead to one correct answer was a new experience when it came to learning math. In the previous section we noted that Anahi seemed to have a positive attitude about her proficiency in math. But what counted as success and being good at math in her high school is revealed in her conception of learning/doing math - *memorizing procedures, getting the answer, and regurgitating the information on exams*. This very view of what constituted math and learning was being shaken by the practices of her new learning environment at RSMC. Furthermore, she found herself in company of peers who were better prepared and more knowledgeable than her, which was also a new experience for her.

Once the culture shock wore off, how did Anahi adapt to this new learning environment at camp? During her first year at camp, Anahi was assigned to a counselor, Mira, who was also a Hispanic female from Anahi's hometown. In our interview, Anahi describes the crucial role that Mira played during the first year at camp. In the script below Mira actively builds a relationship with her mentee, Anahi, to help her construct a different way of learning mathematics and to support her math learning identity. The

script also illustrates how RSMC makes relational resources available to campers through one of its structural components – counselors. By carefully assigning counselors to each group, RSMC provides an essential support structure to new and returning campers.

Anahi: And so my counselor, uh, comes and she, she talks to me the process. She's like, "Do you understand the flow? I'm making sure that every single person," I think she saw I'm very confused [inaudible 00:08:46]. She was like, "Okay. I want you to understand the problem before you leave here because you're going to write it up."

Anahi: And walks me through every single steps like, "Do you understand every step and why things happened in this manner?"

Anahi: ... don't know how they knew it out of like the blue and I had no clue."

Anahi: And she's like, "This is how it is. Not that they know the answer. They're just guessing what the answers gonna be,

Anahi: ... and trying it to see if it works out." I was like, "Oh, if they're guessing, I can totally guess, too."

Anahi: I will guess for the next session.

Anahi: So for Number Theory, I ended up being that. I started learning how to ... It was matter of just trying things,

Anahi: ... and seeing how it worked.

Anahi: And, I, I think I got lucky in the form that I had a really good counselor who was coaching me through the steps,

Anahi: ... that made me feel at ease.

Anahi: I don't think if I wouldn't have had that concept, I might have been just as loss and I'm like, "I can't do this. I give up."

Anahi: Uh, but she, she did a really good job explaining that process.

The script above illustrates that the relationship that Mira built with Anahi served multiple purposes. One purpose it served was that Mira took on a role of a coach and mentor during her interactions with Anahi helping her through challenging moments of learning. Another purpose it seemed to serve was providing Anahi with a sense of belonging in mathematics and at her new learning environment. When Anahi was feeling frustrated and lost during her classes, it was Mira who counseled her on how to adapt to her new environment by developing a skill set which is more conducive to learning at camp. Mira helps Anahi overcome the intimidation that she was feeling among her new camp peers. The example above shows the importance of having counselors and the

support structure they offer to new campers. We also note that by building a strong relationship with her counselor, Anahi did not give up in the face of a challenging circumstance, instead she persisted and came to shift her understanding of learning math. In this manner RSMC makes available relational resources to campers that lead to fostering “social relationships to sustain [the] efforts” of campers during difficult moments of learning and doing some very challenging mathematics (Nasir & Cooks, 2009). Furthermore, the scripts above also highlight the importance of material resources that were offered to Anahi at RSMC in the form of challenging, non-standard curriculum. The above illustrates that the challenges in the material resources and the support structures in the relational resources to persist through the challenges were essential in creating opportunities through which Anahi was on a path to shift her MLI trajectory. The above is just one example of how RSMC offers identity resources to its students. In the following section I will discuss various practices of RSMC through which the core identity resources were made available to and taken up by Anahi during her time at RSMC.

### **Experiencing RSMC – taking up the identity resources**

In the figure below I will argue that the three core identity resources as described in Nasir and Cooks (2009) were made available by RSMC (through its various components) and taken up by the participant as she recalls her past experiences at the camp. Note, that the availability of and the value of these resources come from the participant herself. The figure includes Anahi’s comments from past and present data sources that illustrate how her pre-MLI was interrupted and shifted on a different trajectory with a new and more profound understanding of herself as a learner. This shift

happened through the practices and characteristics that Anahi encountered at RSMC and through her interaction with the practices. The data sources from which Anahi's quotes are used in the figure include - past data (camp evaluation, 2001) and present data (interview 1 over Skype and interview 2 via email).

Characteristics/Practices of the Learning environment	Behavior developed/supporting behavior	Measuring success/rewards given for the successful behavior
<p>Peers who are better prepared than me</p> <p><b>[Relational Resource:</b> Interaction with study group members/peers in class]</p> <p><i>“They had quickly got down to the numbers and learn the process and started answering stuff on the board. I’m like I don’t even know how to contribute.”</i></p> <p><i>“... don’t know how they knew it out of like the blue and I had no clue”</i></p>	<p>Was humbled; how to learn by observing others and by participating with them in the process of problem solving through discourse</p> <p><i>“I went from thinking I was an expert at math to meeting people I thought were the real experts.”</i></p> <p><i>“I learned by observing... Nobody ever solved every problem by themselves, that was a big learning point”</i></p> <p><i>“To attempt solving the problem and participate in class. Both to help others and learn from others.”</i></p> <p><i>“I like ... discussing with other groups proofs you did the night before. This way we get different perspectives from other people.” p.1, camp evaluation, 2001</i></p>	<p>Learning new ways to think about a problem from others. Understanding a concept.</p> <p>Learning from others through participation and discourse and knowing how to do so became a part of her, which helped her with her peers in college as well.</p> <p><i>“I was not only learning new methods to solve the same problem but teaching others how my brain solved the problems and how they could approach it”</i></p> <p><i>“So how to interact with people was ... and make those connections... that is like the number one thing that applied from camp on forward”</i></p> <p><i>“Um, which it ... they kinda carried on to college”</i></p>
<p>Camp invites former campers to be counselors to the new cohort of campers</p> <p><b>[Relational Resource:</b> Interaction with counselors]</p> <p><i>“I was paired up with my very first counselor, who was also happen to be from the same city where I lived... And she spoke Spanish”</i></p> <p><i>“Summer 4-6 I saw myself as an instructor gaining knowledge by teaching others and helping guide students.”</i></p>	<p>Seeing counselor as a role-model, mentor, and taking up the offered support to improve learning</p> <p><i>“[Mira] is the best counselor I could have had.” – p.1, camp evaluation, 2001</i></p> <p><i>“And, I, I think I got lucky in the form that I had a really good counselor who was coaching me through the steps, ... that made me feel at ease”</i></p> <p><i>“She was, uh, I think I believe she’s going to [University C] at the time...”</i></p> <p><i>NN: Yeah. So it’s kinda of a role model thing, Anahi: Yes.</i></p>	<p>Building positive relationships.</p> <p>Understanding how to learn math in different ways. Finding a role-model.</p> <p>Became a counselor at RSMC later to help new campers, which was a reward in itself.</p> <p><i>“as a counselor, I had to work the hardest to balance every group member different way of learning and instill my own teachings.”</i></p> <p><i>“After seeing how much more I learned through problem sessions and group meetings, when asked for help, I gave people hints and similar problems, and let them discover the solution. I felt I was helping them more in that way.”</i></p>

Figure 19. Anahi’s MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed/supporting behavior	Measuring success/rewards given for the successful behavior
<p>Camp fostered a non-competitive and collaborative environment</p> <p><b>[Ideational and Relational Resources:</b> ideas about what is valued and good in this community of practice]</p> <p><i>“Math Camp is <u>not</u> one of those places where they give you all these grades and tell you where you rank next to anyone else”</i></p>	<p>Understanding that no one can do everything by themselves, it’s okay to ask for help, and it is very important to help others.</p> <p>Learned to collaborate and not compete with peers.</p> <p><i>“I learned by observing... Nobody ever solved every problem by themselves, that was a big learning point”</i></p>	<p>Forging collaborative relationships</p> <p><i>“To attempt solving the problem and participate in class. Both to help others and learn from others.”</i></p> <p><i>“collaboration was expected, and I gladly accepted help”</i></p>
<p>Study Groups: dividing campers into study groups and assigning a counselor as a mentor with the expectation of working together and helping each other learn.</p> <p><b>[Material, Ideational and Relational Resources:</b> mandatory study groups are a structural/organizational component of RSMC – learning takes place through study groups, which makes it a material source. It may also be considered a Relational Resource because it provides an opportunity to build relationships with peers. It is also an ideational resource because the expectation is to collaborate with your peers, which sets the tone of what is valued at camp]</p>	<p>Bonding with your group mates through the process of doing some very challenging math together. <i>“[I felt] Super excited when I solved a problem because the problems took much longer to solve and as I tried the problems I didn’t know if I was going in the right direction. I would attribute my success to the many people who helped me when I was stuck, and to my persistence to learn and solve the [problem]”</i></p> <p>Forming comradery, friendships with your group mates through learning from each other and sharing aspirations.</p> <p><i>“It created a bonding with my team. I not only learned about them and made friends but I learned about what I like and don’t like, what I knew and was unaware of, and helped me compare my aspirations.”</i></p> <p><i>“The experience was different because conversations became very broad. After spending so much time with the same people in one room you end up talking about anything and everything. At the end of camp you knew so much about these people it felt you grew up with them.”</i></p>	<p>Forging positive and collaborative relationships with peers and learning how to form such relationships.</p> <p>Persisting through challenging problems</p> <p>Experiencing that forming study groups helps learn.</p> <p><i>“So how to interact with people was ... and make those connections... that is like the number one thing that applied from camp on forward”</i></p> <p><i>“Keep trying, you are not alone. By bonding with others you will gain the support you need and have a better shot at succeeding.”</i></p> <p>Group mates enjoy working on problems together. They push each other to do more than just what is assigned.</p> <p><i>“There was always students who pushed themselves to do more and more”</i></p> <p><i>“I’m looking around and everyone else is like looking for more, more... And it kinda rubs off on you.”</i></p>

Figure 19, Continued. Anahi’s MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed/supporting behavior	Measuring success/rewards given for the successful behavior
<p>Camp fosters aspects of growth mindset</p> <p><b>[Ideational Resource]</b></p>	<p>Working hard and persisting in solving problems Learning from others</p> <p><i>“[I felt] Super excited when I solved a problem because the problems took much longer to solve and as I tried the problems I didn’t know if I was going in the right direction. I would attribute my success to the many people who helped me when I was stuck, and to my persistence to learn and solve the [problem]”</i></p>	<p>Learning that hard-work, persistence, and collaboration lead to success</p> <p><i>“Keep trying, you are not alone. By bonding with others you will gain the support you need and have a better shot at succeeding.”</i></p>
<p>Camp offers a challenging, non-standard curriculum that fosters creative thinking, persistence, and broad understanding of the field of mathematics</p> <p><b>[Material Resource]</b></p> <p><i>“Mathematica was a new experience for me. I have never taken a course on computers so this was an interesting class.”</i> p. 1, camp evaluation, 2001</p> <p><i>“This [Honors Seminar] was a class of seeing things from different points of views, for example how the different types of people work, their brains, stories.”</i> p. 1-2, camp evaluation, 2001</p> <p><i>“I enjoyed Research Topics... The project idea is really neat. I got to learn different topics about math more thoroughly.”</i> p. 1, camp evaluation, 2001</p>	<p>Persistence, creative thinking, broader understanding of math</p> <p><i>“I went from thinking I knew everything about math, to knowing I only knew one small concept of the overarching hierarchy that constitutes mathematics. [RSMC] not only enhanced my mathematical competence, it helped me see where I really stood in the mathematics realm. This eye-opening experience helped me try harder – there was so much to learn and I had barely touched the surface.”</i></p> <p><i>“[RSMC] did this by introducing me to concepts like mathematica (coding), graph theory (and its applications), [analysis] (calculus levels above my high school experience), and number theory (the class that proves what I took for granted).”</i></p>	<p>Learning a new concept. Understanding a concept more deeply. Understanding what constitutes math</p> <p><i>“This camp has been a great new experience for me...In this camp problems are worked out from a different perspective.”</i> p.1, camp essay, 2001</p> <p><i>“After camp, to learn math was to see the role numbers, multiplication, graphs played in life. To learn the roles, one had to be strategic, try new concepts, prove it was true or false, and know that they may or may not find the answer, but even in failing to prove it, you had one less strategy to solve.”</i></p>

Figure 19, Continued. Anahi’s MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed/supporting behavior	Measuring success/rewards given for the successful behavior
<p>Teaching practices at RSMC: Teachers at camp give agency, build confidence, offer encouragement, create a positive and safe learning environment where it's okay to make mistakes  <b>[Ideational and Relational Resource]</b></p> <p><b>Following are some comments written by Dr. Mark Weitzman in one of Anahi's journals</b>  <i>"[Anahi], you've been incredible! I was so impressed by how well you summed up everything for the group...you've developed as a leader, teacher, and role model for all younger students "</i> p. 7, Journal, 2006  <i>"[Anahi], you have become an incredible leader for camp. I'm so impressed how you set a quiet example, and encourage everyone. Your group is fabulous. I think a key is how you respect each person's ability."</i> p. 15, Journal, 2006</p>	<p>Not being afraid of making mistakes.          Developing a view that every failed attempt offers something new to learn.          Seeing oneself as an active participant in the practice of doing mathematics  <i>"[I] learned mathematics requires guessing and testing and trying until something works out. As a camper I was simply expected to try, so I would pick a problem I thought I had a good shot of solving and tried. I often got stuck, but that was also expected."</i>  <i>"I changed my perception that students simply observe and memorize to students participate and solve problems in different methods."</i>  <i>"Before [RSMC] I never thought I could stand in front of a board and take over a class."</i></p>	<p>Not being afraid of anything when learning.          Internal understanding and learning is a reward in itself.  <i>"After camp, to learn math was to see the role numbers, multiplication, graphs played in life. To learn the roles, one had to be strategic, try new concepts, prove it was true or false, and know that they may or may not find the answer, but even in failing to prove it, you had one less strategy to solve."</i>  <i>"I think [RSMC] intends to let students think and learn for themselves, whichever their approach. They do this by providing different ways to learn and letting the students seek the help they desire from the method they prefer."</i></p>
<p>Organizing Weekend Trips where you participate in team-building activities.</p>	<p>Seeing peers in a different light by noticing people may be good at different things and have different skills. Learning to appreciate the diversity in people.  <i>"It just, uh, you learn other things from other people that you see them in a different light and a different setting,... that I really appreciated seeing that."</i></p>	<p>Experiencing the joy of bonding with others by sharing new and familiar experiences, she replicated these activities with her family and friends in college.  <i>"... I kinda brought that [going on weekend trips] into my family as well... And when I started like going to college and going working, um, I was like, Mom, Dad, let's go bowling. And they're like, What? We've never done this before."</i></p>
<p><b>MLI (AA/AC) being developed (math competence and self-perceptions as a learner aspects of MLI):</b> The realm of mathematics is huge and there's so much to learn. I can be an active participant in this field by persisting, working hard, learning from others, creating collaborative relationships, not being afraid to try something new, forming learning groups with peers who believe in supporting each other, giving back to the community by being a mentor or helping someone new to the field.</p>		

Figure 19, Continued. Anahi's MLI during/post RSMC

The figure above shows the practices of Anahi's RSMC camp environment, the behavior that they developed in her, and how she came to measure her success in such a community. The figure also illustrates how the core identity resources were made available to Anahi through the practices of RSMC. Through Anahi's interaction with RSMC's practices, her pre-MLI was interrupted and shifted on a different trajectory with a new and more profound understanding of the field of mathematics and herself as a learner.

**Racial, class, national origin, and/or gender 'storylines' disrupted at  
RSMC**

The following remarks about gender, class or ethnicity during our interview portion of post-MLI lead me to conclude that Anahi was trying to say that she found in her counselor Mira a real role model of a Hispanic woman who was successful. Unlike her earlier perception where she thought being Hispanic from a low-income family was a constraint to being successful and had something to do one's ability to learn and succeed, having found a counterexample in her counselor Mira, Anahi no longer subscribes that view.

Narratives of gender/ethnicity/class/national origin
<p>I was paired up with my very first counselor, who was also happen to be from the same city where I lived... And she spoke Spanish”</p> <p>“she was also Hispanic”</p> <p>“meeting the counselor was a very, very good experience 'cuz when I had instantly clicked with her”</p> <p>“I felt that she went above and beyond her duties of a counselor... to make sure that you were not only happy and learning”</p> <p>“She was, uh, I think I believe she's going to [University C] at the time... What ... coming from an unrepresented school in, in [City X], I'd never even heard of [University C] I had no idea or sort of idea what it was... So it was from her that I learn about such schools as well”</p> <p>And she was the one that started telling like, "You should consider these schools Like I know you don't feel like you're up to the level, but, ... you'd never know until you give it a shot."</p> <p>“Um, it, it was a [inaudible 00:35:16] to just open my eyes to the world that she was currently living in ... or experiencing by being away from home in [...]. Uh, by going to a school of this caliber. By just showing you everything that she had learned”</p> <p>NN: Yeah. So it's kinda of a role model thing,</p> <p>Anahi: Yes.</p>
<p><b>MLI (AA/AC) (narratives of gender/race/class aspect of MLI) being developed:</b></p> <p><i>Hispanic women from low income families can be successful and being such a woman myself, I can be successful too.</i></p>

Figure 20. Anahi’s MLI (narratives of gender/ethnicity/class) post RSMC

### The shift in Anahi’s MLI

Anahi went from having a very narrow view of mathematics (*solving for  $x$ ; algebra & geometry; problems always having an exact answer*) and what it means to be successful in it (*solving lots of problems quickly; memorizing teacher’s procedures and formulas successfully; getting good grades*) to a much broader and realistic view of what constitutes the realm of mathematics (*the underlying structure of numbers; applications of math in different fields*) and what does it mean to be successful in it (*understanding why a method works, being an active participant, learning from peers and through different perspectives, taking risks, persisting, thinking creatively and deeply; developing internal understanding*). As noted earlier, Anahi had a very naïve and limited view of being “good at math”. After attending RSMC, she developed a much more realistic understanding of where she stood (she had barely touched the surface of a vast discipline)

and what she needed to do to further her knowledge (work harder, persist, push herself to do more, learn from others through discourse, form mutually supportive study groups, not be afraid to make mistakes). Anahi developed a set of study skills and motivation to persist in doing math when it became challenging. She learned at camp how to deal with failure, the fear and the discomfort that comes with being in an uncharted territory such as not knowing ahead of time that whether a problem will have a solution at the end. She also experienced the joy of problem solving that does not require external motivational factors like grades. Experiencing internal understanding, sharing it with peers and teachers, and mentoring the new campers to develop their own problem-solving skills was reward enough to keep going. The narrative on gender/ethnicity/class suggests that her finding a successful role model in a person of same gender, class, and ethnic background was crucial to her identity development and understanding that she wasn't an exception among the Hispanic women and that others in her community could be successful too. This finding has implications on creating and maintaining a diverse student body at RSMC or any other informal learning space. It also has implications that diverse and successful alumni can serve as role models to new campers.

### **Higher Education Trajectory upon leaving RSMC**

What experiences led this young Hispanic girl from a modest financial background to become a successful engineer? Did RSMC have any impact on the higher educational/career paths that Anahi took? If so, what? To answer these questions, I explored the construct of social capital in terms of the resources available to and accessed by the participant through social networks (e.g. parents, relatives, friends, acquaintances, peers, teachers, mentors, and organizations) before and after being a member of RSMC

towards her status attainment (education/career) goals. This section describes the higher education/career trajectory that Anahi envisioned for herself prior to RSMC experience and the shift that took place in this trajectory during RSMC. All the quotes that appear in this section are from the survey and the two interviews.

### **From a modest plan to a bigger dream**

In order to determine the impact of RSMC on Anahi's SC and consequently on her higher education/career trajectory, I asked her to recall her career aspirations before coming to RSMC and describe if RSMC had any influence in realizing or changing those aspirations. The following tables show examples of utterances from her survey and interviews that lead me to conclude that before coming to RSMC Anahi wanted to be an engineer but her plan to realize this aspiration was to attend a local college in her neighborhood. This is as far as she dreamed based on the resources she accessed in her immediate social capital such as her uncle and her school counselors. However, RSMC disrupted this trajectory for Anahi by expanding her social network and making available to her resources that would open up a world of opportunities, broaden her horizons and her academic preparation, give her the confidence to dream bigger, and help her realize her true potential.

Table 5  
*Anahi's Pre-RSMC SC*

Before RSMC: education/career trajectory	Participant utterances	
Aspired to pursue STEM but lacked guidance	<i>"Engineer – because my favorite uncle was an engineer..."</i>	<i>"...nobody really addressed college and future plans. In high school a counselor took me under her wing and guided me"</i>
Limited social capital and motivation	<i>"I was brought up in an underrepresented school where most people drop out and a large portion attend technical colleges due to financial constraints"</i>	<i>"Coming from an underrepresented high school you never hear anyone saying I want to be a doctor, I want to go to Stanford, etc."</i>
Limited social capital kept from dreaming bigger	<i>"I had heard of MIT since I was interested in engineering and google searches would bring up the school, but never considered applying since 1) it was expensive and 2) I had no idea how to apply."</i>	<i>"...studying close to home because everyone stays close..."</i>
Planned to attend a local college	<i>"One day [Mark, the camp director] approached me and asked me where I was applying to school, I mentioned the few that I knew, all locations close to home."</i>	

Table 6  
*Anahi's Post-RSMC SC*

During/Post RSMC: education/career trajectory	Participant utterances		
RSMC significantly improved my academic preparation	<i>"Group study and problem solving sessions helped change the way I approached problems and my career aspirations."</i>	<i>"My entire concept on 'math being easy' was turned upside down."</i>	<i>"In these sessions I had to solve number theory problems, Mathematica, etc., problems where I had no prior experience"</i>
RSMC pushed me to realize my potential	<i>"Everyone was independent, self-driven, and it pushed me to think of what I wanted to do for myself."</i>	<i>"It forced me to first teach myself the process which up to that point had previously been given by my teachers through guides"</i>	
RSMC expanded my social capital	<i>"Counseling on universities, information on how to fill out applications and list of scholarships I was not aware of. Some counselors even offered to review my application essay and write recommendation letters"</i>	<i>"[Mark] ...wrote a letter of recommendation for me ...[Mira] (my counselor at the time) walked me through the process of applying to college and made me aware of things like FAFSA and others..."</i>	<i>"It <b>extended my social network</b> to include people who had <b>high career aspirations</b>. Coming from an underrepresented high school you never hear anyone saying I want to be a doctor, I want to go to Stanford, etc."</i>
RSMC gave me role models to follow in STEM areas	<i>"I had never been surrounded by people who were ambitious and all well positioned to attend flagship universities"</i>	<i>"She [Mira, the counselor] was, [...] I believe she's going to [University C] at the time... What... coming from an unrepresented school [...], I'd never even heard of [University C] ...So it was from her that I learn about such schools..."</i>	<i>"Everyone was independent, self-driven, and it pushed me to think of what I wanted to do for myself."</i>
RSMC broadened horizons and gave confidence to dream bigger	<i>"Thanks to [Mark] I learned about ivy league universities...mentioned Yale, Rice, and MIT. The only Yale I knew was 'jail' and that wasn't a good place, and the only rice I was familiar with was the one I ate at home. I told [Mark] I wasn't sure about those schools and he told me to consider..."</i>	<i>"Because of [Mark], I applied to Rice and was waitlisted. It may not sound like a big achievement, but just that fact that I ... went through the application process alone and managed to even be considered is a big feat."</i>	<i>"...attending [RSMC] and participating in the Siemens Competition was an opportunity I would have never experienced had I not attended [RSMC]."</i>

The quotes above illustrate that RSMC had a crucial impact on Anahi's higher education/career trajectory and the decisions she made regarding applying to some of the top-ranked institutions of higher learning. For Anahi it was the following aspects of camp and people that impacted her SC and altered the course of her educational/career journey:

- mentorship from Mark, the camp director, in considering top-ranked schools for higher education, the confidence he had in her, and the recommendation letters he wrote for her;
- finding a role model in her counselor Mira and the actual guidance received by Mira and other counselors in filling out college applications, applying for scholarships to pay for college, and recommendation letters the counselors wrote for her;
- being surrounded by self-driven and motivated group of peers;
- academic preparation received at the camp;

#### **RSMC characteristics/practices valued by the participant**

What practices and components of RSMC does Anahi value and credit, if any?

This question seeks to find the characteristics and elements of RSMC's environment that are valued by its female participants from low SES and/or minority backgrounds and led to impact on their MLI and higher education/career trajectories. In this section I identify particular practices that Anahi values and mentions either in her "then" data (journals, evaluations) or in her "now" data (survey and interviews). The following figure shows excerpts from Anahi's past data sources in which she mentions aspects of camp that she likes or appreciates. These are some of the practices that led to RSMC's impact on Anahi's MLI and SC discussed earlier.

RSMC Practices/Components Valued	Participant utterances	Data Source
Teaching practices ( <i>deep understanding, taking ownership of the work, clear explanations, learning from different perspectives</i> ) at RSMC	<p><i>"When I had [Tony] for Analysis I thought his way of teaching was amazing. He would start out at one point...and helped us run through the rest. So actually, we would be teaching ourselves"</i></p> <p><i>"I did like when [Mark] would explain things step-by-step because I actually followed..."</i></p> <p><i>"[Dan and Nora] are really nice ... liked the way they explained the problems ..."</i></p> <p><i>"I also likes the way he [Tony] doesn't tell us the answers, he only insinuates it."</i></p> <p><i>"This camp has been a great new experience for me...In this camp problems are worked out from a different perspective."</i></p> <p><i>"I can truly say that I know more things now because I have been taught why problems have the answer they have"</i></p>	Data Source: Camp essay, 2001, Camp evaluations, 2001, 2004
Camp Curriculum	<p><i>"Number Theory class is awesome..."</i></p> <p><i>"I enjoyed Research Topics... The project idea is really neat. I got to learn different topics about math more thoroughly."</i></p> <p><i>"Mathematica was a new experience for me. I have never taken a course on computers so this was an interesting class."</i></p>	Data Source: Camp evaluations, 2001, 2004
Camp Counselors	<p><i>"[Mira] is the best counselor I could have had. She really helped our group out and brought us snacks"</i></p> <p><i>"[Hima] was a good problem session teacher..."</i></p> <p><i>"It's almost the end of camp. Unbelievable. It seems like not too long ago was the 1<sup>st</sup> day the campers arrived...well my group continues to amaze me...man am I going to miss having them around &amp; checking up on them. It's strange how quickly one gets attached to so many people in such a small amount of time."</i></p>	Data Source: Camp evaluation, 2001, Journal, 2006

Figure 21. RSMC components valued by Anahi as noted in her past data sources

RSMC Practices/Components Valued	Participant utterances	Data Source
Study groups & Problem sessions (bonding, learning through discourse and collaboration)	<p><i>"I liked the group I had...I had a lot of fun with this group...our group got a lot of work done when we didn't fool around..."</i></p> <p><i>"I like the idea of discussing with other groups proofs you did the night before. This way we get different perspectives from other people."</i></p>	Data Source: Camp evaluation, 2001
Colloquia (Experiences exposing to STEM ideas. Female speakers in STEM mentioned)	<p><i>"[Sarah Cole] showed us really cool chips from computers and gave us examples of how to program"</i></p> <p><i>"[Delores Fernandez] explained really well how the connections go from one place to another"</i></p>	Data Source: Camp evaluation, 2001
Social aspects at RSMC (weekend trips, socializing with camp faculty and peers, living in college dorms)	<p><i>"[Mark] I like your house. I like the idea of having ice cream and then going to the park to watch some fireworks"</i></p> <p><i>"The trip to [xyz hiking] was fun...it was like a little world with only us, the campers in it"</i></p> <p><i>"The Canoe trip Rocked, it was a totally new experience for me ...everyone felt proud of themselves when they filled up a canoe"</i></p> <p><i>"The weekend trips are great...allows students to bond with other people"</i></p> <p><i>"The idea of living out of home and by yourself is GREAT..."</i></p> <p><i>"I learned to be independent of myself, and to be more courteous and responsible. Here I experienced how I would probably live when I go to college"</i></p>	Data Sources: Camp evaluation, 2001, Camp Essay, 2001

Figure 21, Continued. RSMC components valued by Anahi as noted in her past data sources

When asked in the recent survey and interviews about the practices of RSMC that Anahi came to value, she identified the following practices - *sense of a collaborative community, study groups and problem sessions, camp curriculum, counselors, and social aspects such as weekend trips and living in college dorms* as most significant for her.

Regarding RSMC creating a sense of a collaborative community, Anahi stated “Collaborative community, one focused on learning from each other and growing together...It forces everyone to work together in groups and sets up weekend events that require partnership and teamwork. It also gives students the liberty to do what they like and think is correct instead of constantly parenting and correcting them.”

With respect to study groups, problem sessions, and the camp curriculum, Anahi mentioned that “Group study and problem solving sessions with other groups helped change the way I approached problems and my career aspirations. In these sessions I had to solve number theory problems, Mathematica, etc. problems where I had no prior experience.” Anahi appreciated these sessions as they afforded her “the opportunity to step up and participate in a stress free environment” and forced her push herself in learning and understanding the concepts which had previously been just shown or given to her by her school teachers “through guides and multiple samples.”

Anahi finds camp counselors to be one of the important components of RSMC. She mentioned in her initial interview that “meeting the counselor was a very, very good experience” for her. Mira, Anahi’s counselor helped through the challenging first year experience she had at RSMC as Anahi notes that “My entire concept on 'math being easy' was turned upside down... my counselor, uh, comes and she, she talks to me the process... I had a really good counselor who was coaching me through the steps,...that

made me feel at ease.” When Anahi was feeling frustrated and lost during her classes, it was Mira who counseled her on how to adapt to her new environment by developing a skill set which is more conducive to learning at camp. In the follow up interview Anahi mentioned that the camp counselors helped break through a previously conceived notion she had where she saw teachers being “at a higher level and ...[having] nothing in common with students”. She then said, “From camp counselors I started ... breaking barriers... I saw the counselors as fellow friends, with immense knowledge, but still humans growing with us and learning and doing their best.”

Anahi also values the social aspects of the camp. In her follow up interview she stated “Loved weekend trips – most were a 1st for me (1st time kayaking, bowling, staying at a cabin)... I definitely self-reflected on the college dorms, I learned the type of person I am, valued help and support”. The following script from Anahi’s initial interview really drives the point home about the importance of the social aspects of the camp.

Anahi: For me, at least, the only other places that I've visited have always been with my family and it's usually just San Antonio and it had been Mexico to go visit more family.

Anahi: Um, it wasn't ever to make a weekend excursion or a weekend trip or to all go bowling or kayaking,

Anahi: ... or anything of that sort. So the very first time that I had even did all of those things of going bowling, going kayaking, and going to a farm in the middle of this gorgeous place and staying at a really nice lodge,

Anahi: ... were they're all first time experiences.

Anahi: Um, and then by that, by that time that all of these experiences ... they kinda accumulate one of each other and I think that Math Camp does a very good job in kinda setting like the first event's gonna be bowling and then the next event is gonna be kayaking, where you kinda need to rely more on your partner and your teammate and the next one's gonna be like the very last one's gonna be like this camping because now by that time everyone should know each other.

Anahi: And they would interact. So they do a very good job of helping you, uh, start meeting other students,

Anahi: ... that you ... are not in your groups or in your classes, uh, but voicing you to participate in something that you may even show additional skills then like there, there was a person who was really good at kayaking.

Anahi: It just, uh, you learn other things from other people that you see them in a different light and a different setting,

Anahi: ... that I really appreciated seeing that.

Anahi: Um, so at camp it, it, it really helped kind of bond me with additional campers and I think it was one of the reasons why I continued coming back to camp so much because we were looking forward to having these additional experiences.

The above illustrates that for Anahi the social aspects of RSMC provided opportunities to bond with peers, value teamwork, and appreciate different qualities and skills of others by seeing the same peers in a different light outside of the classroom. Such an experience may be seen as having an overall impact on building character, affording different students opportunities to use other abilities, as well as providing a setting for students to work together.

### **Summary of RSMC practices valued**

Some of the same practices that were valued by Anahi when she was a high school student attending RSMC were also valued by her in her recent retrospective interviews and survey. The figure below summarizes Anahi's valued practices about RSMC from the past and the present. The highlighted cells indicate the common ones over time. These are elements of RSMC that led to the impact on Anahi's MLI and higher education/career trajectory overtime.

Table 7

*Summary of RSMC practices/components valued by Anahi*

RSMC Practices/components valued in the Past (while attending camp during high school)	RSMC Practices/components valued in the Present (in retrospect)
Teaching practices ( <i>deep understanding, taking ownership of the work, clear explanations, learning from different perspectives</i> ) at RSMC	Sense of a collaborative community at RSMC ( <i>provides help and support, encourages independent thinking, and values individual choices</i> )
Camp Counselors	Camp Counselors
Study groups & Problem sessions ( <i>bonding, learning through discourse and collaboration</i> )	Study groups & Problem sessions ( <i>bonding, learning through discourse and collaboration</i> )
Camp curriculum	Camp curriculum
Social aspects at RSMC ( <i>weekend trips, socializing with camp faculty and peers, living in college dorms</i> )	Social aspects at RSMC ( <i>weekend trips, socializing with camp faculty and peers, living in college dorms</i> )
Colloquia ( <i>Experiences exposing to STEM ideas. Female speakers in STEM mentioned</i> )	

### Case Summary

According to Anahi RSMC played a significant role in changing her perceptions about learning math and herself as a learner of math i.e. MLI development. Anahi went from having a narrow view of mathematics and what counts as success to a much broader and realistic view of what constitutes the realm of mathematics and what does it mean to be successful in it. The embedded-case of Anahi illustrates that how over the course of her affiliation with RSMC, Anahi became more connected to the practice of Mathematics and developed a broader and holistic learning identity in the context of math in particular and STEM in general. The finding about how due to experiences at RSMC Anahi was able to change her perception of being a learner in mathematics coming from an underrepresented, low-income background is most powerful. Anahi found in her counselor Mira a real role model of a Hispanic woman who was successful. Her earlier perception of herself as a learner of mathematics was that she was good at math despite of her background and saw being Hispanic from a low-income family was a constraint to

being successful. Having found a counterexample in her counselor Mira, Anahi no longer subscribed that view. This seems to suggest that she came to the conclusion that the properties of race, ethnicity, class, and gender had nothing to do with her abilities to understand and learn math.

Although before coming to RSMC Anahi wanted to be an engineer but she lacked guidance on how to realize this aspiration. Her plan was to attend a local college in her neighborhood. This is as far as she dreamed based on the resources she accessed in her immediate social capital. However, RSMC disrupted this trajectory for Anahi by expanding her social network and making available to her resources that would open up a world of opportunities, broaden her horizons and her academic preparation, give her the confidence to dream bigger, and help her realize her true potential. In this way, RSMC altered the course of Anahi's educational/career journey. We may note from the perspective of this participant how access to and use of embedded resources in RSMC enhanced Anahi's chances of attaining better statuses with respect to higher education/career related decisions such as applying to some of the top-ranked institutions of higher learning as a first step in her journey to becoming a successful engineer.

The particular practices and components of RSMC that Anahi came to value over time as mentioned either in her past data (essays, evaluations, journals) or in her present data (survey and interviews) are included below. These are elements that led to the impact that RSMC had on Anahi's MLI and higher education/career trajectory.

- Teaching practices such as emphasis on deep understanding, not just learning how but also why, taking ownership of the work, clear

explanations provided by teachers, and learning from different perspectives.

- Camp colloquia talks providing experiences where students are exposed to STEM ideas and research by speakers from different STEM fields. Anahi took particular note of female speakers in STEM and mentioned how much she enjoyed these talks at the colloquia in her camp evaluations.
- Study groups and problem sessions that encourage bonding, learning through discourse and collaboration among peers.
- Camp curriculum that is challenging, non-standard and includes topics such as number theory, analysis, mathematica to which students aren't normally exposed to in most high schools.
- Counselors who serve as mentors and role models to the campers and provide counseling to campers about any issues they may be experiencing.
- Social aspects such as weekend trips that provide opportunities to bond with peers, value teamwork, and appreciate different qualities and skills of others. While living in college dorms instills independence in campers and affords them an opportunity to envision a life in college.
- Sense of a collaborative community that provides help and support when needed, encourages independent thinking, and values individual choices.

## **Case 2: Hima**

I first met Hima over Skype for our first interview. Hima is an Asian woman in her early thirties, with a quiet disposition. Hima grew up in an urban area in China and came to U.S. with her family on a F-2 visa. Her father was on a non-immigrant F-1 student status. Her father had a Bachelor's degree from China in Engineering and had decided to come to US in the hopes of creating a better future for his family. Hima's family did not have many financial resources or any relatives in the US who could offer any support. While her father was a student, her mother worked as a dishwasher and a waitress in restaurants to make ends meet and support the family. Hima recalls living in a trailer home during this time. The initial few years in the US were not very easy for Hima. She recalls "It was ... just as frustrating watching my parents get the confused with language barriers (and perceived discrimination/disrespect) as it is having to go through that myself." It was difficult for her to make friends during middle school and she was often called names. Furthermore, the uncertainty of being dependents on a non-immigrant status with limited resources (not knowing if they will make it in the US or may need to return back to China) was especially trying as Hima recalls "There was definite financial and psychological hardship on the entire family". However, Hima and her family braved through the difficult times since then. She graduated from one the renowned institutions in U.S., we shall refer to it as University B, in 2005 with a Bachelor of Science degree in Biology. After which she pursued her graduate studies in medicine and earned an MD/MPH dual degree and a Masters in Epidemiology also from one of the top-ranked schools of Medicine. She is a successful physician and is currently working at one of best medical centers in the U.S.

### **Trajectories of identities: MLI co-construction and shifts**

In this section I will describe the story of Hima, a young Immigrant Physician, and her experiences at an informal math summer program - RSMC during her high school and undergraduate years. In order to determine the identity trajectory that RSMC helped create for Hima, I will first explore the path she was already on prior to coming to RSMC. This will entail describing her perceptions about learning math and herself as a learner of math in her high-school classroom. Next I will describe the shift in the MLI trajectory that RSMC helped create for Hima.

#### **Pre-MLI: What constitutes learning in Math?**

In order to determine the impact of RSMC on Hima's MLI, I asked her to recall her beliefs about learning and doing math prior to coming to camp as well as describe her perceptions of herself as a student of mathematics. We shall call this Hima's Pre-MLI. The retrospective interview, correspondence, camp evaluations, and journals are the primary data sources for determining her Pre-MLI.

The following figure shows an example of utterances from her interviews that lead me to conclude that for Hima prior to RSMC learning and doing math meant excelling in solving a lot of problems quickly in a competitive environment by competing against peers, participating in competitions, focusing on Algebra, Geometry, and Calculus by memorizing and applying formulas to excel and mimicking procedures well enough to solve the same type of problems that are shown as examples by the teacher without being creative. She saw math itself as something non-creative that required solving a lot of problems with a fixed structure and required good memory.

<b><i>Perceptions about learning/doing math before RSMC</i></b>	<b><i>Participants' utterances</i></b>		
Solving a lot of problems quickly in a competitive environment.	<i>"I would say it's solving problems...the time pressure..."</i>	<i>"it's also the competition aspect cause I did a lot of math competitions so we did a lot of that..."</i>	<i>"you know, super competitive with each other"</i>
Mimicking procedures well enough to solve the same type of problems in non-creative ways	<i>"you give them samples, examples of how to solve a problem and you can solve the same type of problem"</i>	<i>"... take one kind of [problem and] try to fit in the other"</i>	<i>"you don't have to get very creative with, you know, thinking about things as much when you problem-solve"</i>
Math is solving problems in a fixed structured way and needs good memory. Doing math is easy and not very creative.	<i>"I think they're more structured... I'm very good at learning the... structure ...of how to solve a problem"</i> <i>"... take one kind of [problem and] try to fit in the other"</i>	<i>"I wasn't very good with memory, like, multiplying things, I'm like, Um... I keep on having to remember what the number is. I'm not very good with the memory"</i>	<i>"you don't have to get very creative with, you know, thinking about things as much when you problem-solve"</i>
Focusing on Algebra, Geometry, and Calculus by memorizing and applying formulas to be successful	<i>"just doing your algebra and your geometry... Calculus is also, like, sort of your standard ..."</i>	<i>"there's a lot of formulation...there's somebody good at doing that [applying formulas] ... You actually do pretty well ..."</i>	
<b>Emerging theme</b>	Memorizing formulas and mimicking procedures to solve similar problems in algebra, geometry, or calculus quickly in a competitive environment. Math itself is solving problems in a fixed and non-creative way and requires a good memory.		

Figure 22. Hima's perceptions about learning/doing math before RSMC

**Pre-MLI: Am I good at math? (Self-perceptions about being a learner of mathematics)**

When I asked Hima to describe her self-perceptions as a student of mathematics prior to RSMC, she said she considered herself a good student. This perception was

partly based on her mindset that she was naturally good at math as she states “It was kind of natural for me...Something I was good at.” In addition, this perception was also based on her meeting the expectations of what was considered “good” at being math at her school. Her school equated competence with memorization of procedures and formulas, speed, high scores on tests, and winning competitions. The students who were considered “good” at math always did more problems than the rest of the peers, tended to work alone, and participated in math competitions. Hima also recalled that because she was good at following procedures and figuring out structure of problems she thought she was good at math. In her interview she mentioned “you can solve the same type of problem ... And I'm really good at it actually ... I'm very good at learning the... structure ...of how to solve a problem ... But then I think the stuff you learn in math camp ... You can't really do that.”

Hima also mentioned that the perception of her peers at school dictated how she felt as a learner of mathematics. In her interview she said “everybody gets kind of falling into a category... Math So I think that's where I kind of ... Falling into that category... It was something you're good at so it was kind of part of your identity in school.” This suggests that Hima felt that she fell into the category of people who are good at doing classroom math and defined herself in terms of that. She wrote in one of her camp evaluations that “at times...high school atmosphere shuns individuals fond of learning” and mentioned in her interview that she felt ashamed of being good at math, “sometimes it's like being a nerd in high school ... It's just kind of, like, a bad thing ...if people finish more proofs than you it's a bad thing [in high school].” Furthermore, Hima mentioned in her interview that in her high school “half the people don't want to be there... They don't

want to do anything”, which implies that her peers in school viewed math as a chore that they didn’t want to do. She felt she was one of the few people who liked math. Therefore, she should find a way to adjust in an environment where people find math a burden and shunned her for liking it because that was the norm.

**Pre-MLI: Subscribing to racial, class, and/or gender ‘storylines’ in the context of learning math**

The following remarks about ethnicity, national origin, or immigrant status during our interview portion of pre-MLI and in a correspondence lead me to conclude that Hima was trying to say that she is good at math because she is from China and is therefore naturally good at it. The remarks also suggest that being an immigrant was hard for her as she was only acknowledged for her math skills by others and found it hard to be accepted for who she really was.

Narratives of national origin/immigrant status/class
<p>“I thought math was something ... was an academic subject I was good at, also I think cause I moved from another country... So that was something I could do... That was kind of, you know, something I was comfortable with... and pretty confident in”</p> <p>“It was kind of natural for me...Something I was good at”</p> <p>“Being Chinese - you are assumed or supposed to be good at math.”</p> <p>“It was ... just as frustrating watching my parents get the confused with language barriers (and perceived discrimination/disrespect) as it is having to go through that myself.”</p> <p>“Being from an immigrant family...I had difficulty adjusting to changes and finding acceptance, especially when I was mostly known for my math skills”</p> <p>“There was definite financial and psychological hardship on the entire family”</p>
<p><b>MLI (A<sub>A</sub>/ A<sub>C</sub>) (narratives of national origin/immigrant status/class aspect of MLI) being developed:</b> <i>I am good at math because I am from another country [China] and math is an academic subject with which I am comfortable and naturally good. People in the US mostly acknowledge me for my math skills.</i></p>

Figure 23. Hima’s MLI (narratives of national origin/ class) before RSMC

The above descriptions of Hima's beliefs about learning and doing math as well as her perceptions of herself as a student of mathematics leads me to conclude that MLI (A<sub>A</sub>/A<sub>C</sub>) Hima constructed in high school prior to attending RSMC was - *I am good at math because I am naturally good at it being from China. I perform pretty well at math competitions. I am good at completing a lot of algebra and geometry problems quickly, and successfully following my teachers' procedures. I belong to a category of a small group of people who are good at math (which is not the norm). Therefore, others see me as a nerd, which is not a good thing. Since I am mostly acknowledged for my math skills, math must be part of my identity.*

### **Post-MLI: After the culture shock: moving onwards and upwards**

The findings in this section illustrate how RSMC help create an inbound STEM identity trajectory for Hima by affording her material, relational, and ideational identity resources (Nasir & Cooks, 2009) throughout her stay. I will show how over the course of her affiliation with RSMC, Hima developed a broader understanding of the practice of mathematics and came to view and appreciate it as a creative discipline that plays a huge part in other fields as well. She came to enjoy problem solving for the sake of it and not as something to be mastered for winning competitions. Hima was accepted at camp for who she was and not just for her math skills. From the beginning she felt that she had a choice in finding out what really interested her instead of pursuing something just because she could do it. She was encouraged to explore different fields such as medicine, physics, engineering, chemistry, international studies and was shown how math could be a big part of any of these fields. Camp afforded her an environment where she could be herself and where she learned that what she *could do* might be important, but what she

wanted to do was more important. As a result of this transformative experience at RSMC, Hima developed a broader and holistic learning identity in the context of math in particular and STEM in general. Hima's retrospective accounts in her interview, survey, correspondence and her handwritten documents (e.g. journals, camp essays, and camp evaluations) from when she was a camper and counselor at RSMC are used as data sources to help tell her story.

### **First year at RSMC - challenges and struggles**

The comments below from Hima's journals, camp evaluations, correspondence, and my interview with her illustrate the challenges Hima faced during her first year at camp.

Participant utterances	Data sources
<i>"I remember that when I was at camp, I had difficulty understanding the concepts and struggled with writing mathematics proofs"</i>  <i>"More than once I got discouraged and felt incompetent with the task"</i>  <i>"the camp was a very different set of problems"</i> <i>"You had to do more than just, like ... You just have to ... think a little more, more creatively ..."</i>  <i>"I think I did discover how people are so smart ... There are definitely really smart people"</i>	Correspondence, Interview
<i>"It has been an overwhelming day...truth tables are new to me..."</i>  <i>"The problem set we got today [in number theory] was quite difficult. Did I say quite? It's more like extremely hard...I feel the whole world is turning back on me"</i> <i>"This has been an extremely intense exercise of mind for me"</i>	Journal, 1998
<i>"...people in my group ...all understood and finished the problem ahead of me and I was stuck, I feel sort of left out"</i> <i>"I'm too much of an independent thinker at times which leads to frustration"</i>  <i>"I guess I know learning is the whole key here, and getting knowledge...is way more important than contrasting my skills with others"</i>	Journal, 1998

Figure 24. Hima's first year challenges at RSMC

From the figure above we may note that during the first year at camp Hima felt overwhelmed, frustrated, and intimidated. The material in her camp courses was quite challenging and new to her. Furthermore, working with problems that required creative thinking and did not follow the cookie cutter structure that Hima was used to at her high school was a new experience for her when it came to learning math. In the previous section we noted that Hima seemed to have a positive attitude about her proficiency in math. But what counted as success and being good at math in her high school is revealed in her conception of learning/doing math - *memorizing procedures, getting the answer, and being fast*. This very view of what constituted math and its learning was being shaken by the practices of her new learning environment at RSMC. Furthermore, she found herself in the company of peers who were better prepared and more knowledgeable than her, which was also a new experience for her. It was difficult for Hima to stop seeing math as a solitary activity in a competitive environment. She had to figure out a way to collaborate with her peers instead of competing against them.

Once the culture shock wore off, how did Hima adapt to this new learning environment at camp? During her first year at camp, Hima needed a mentor, someone who could take her under his or her wing and give her the tools to survive in camp. Hima's number theory professor, Mark Weitzman, was just this person for her. In our interview and other documents, Hima describes the crucial role that Mark played during the first year at camp. She recalls Mark with a fondness and smile on her face as she states "Dr. [Weitzman] ... I don't think I can stop saying good things about him...he's definitely very positive... he's the type of...teacher with an attitude... if anybody can ever learn to do it...everybody should be able to do it and be wonderful." Hima recalls

that when she was at camp Mark “made sure to remind [them] every day that we were there to learn, not to see who came up with the solution the fastest.” He took the time to read and respond to every camper’s journal. In Hima’s journal I found entries where she reported feeling frustrated because she was working alone, Mark would remind her to “work together with [her] group.” He often inquired how things were working with her group mates and responded to her proofs and questions that she would write about in her journals. In a correspondence Hima wrote “More than once I got discouraged and felt incompetent...Dr. [Weitzman] was often there to remind me of the beauty inherent in the thinking process itself...he made sure we were all winners for being explorers and thinkers and for persevering through difficult tasks.”

From above we can see that Mark actively builds a relationship with his student and mentee. When Hima was feeling frustrated and overwhelmed during her classes, it was Mark who counseled her on how to adapt to her new environment by collaborating with others which is more conducive to learning at camp, by persisting when faced with a difficult problem, and by giving her constant feedback on the proofs she included in her journals. Mark helps Hima overcome the intimidation that she was feeling among her new camp peers by reminding her often that learning together was more important than competing. He helps Hima to construct a different way of learning mathematics, to see the value in collaboration, to help her see the joy in the process of thinking itself, and to provide her the necessary support. We also note that by building a strong relationship with her professor, Hima did not give up in the face of a challenging circumstance, instead she persisted and came to shift her understanding of learning math. Through this relationship she also learned about what was valued in the RSMC community. In this

way Mark served as an ideational resource for Hima. This illustrates how RSMC makes relational and ideational resources available to campers through its structural components – camp faculty and the practice of journaling. By encouraging camp faculty to take on the role of a mentor when needed and by having the camp director read and respond to the campers' journal entries, RSMC provides essential support structures to new and returning campers.

### **Experiencing RSMC – taking up the identity resources**

In the table below I will argue that the three core identity resources as described in Nasir and Cooks (2009) were made available by RSMC (through its various components) and taken up by the participant. Note, that the availability of and the value of these resources come from the participant herself. The figure below shows how the participant's pre-MLI was interrupted and shifted on a different trajectory with a new and more profound understanding of herself as a learner. The data sources from which Hima's quotes are used in the figure include - past data (journals, camp evaluations) and present data (correspondence, interview).

Participant utterances	Characteristics/Practices of the Learning environment	Behavior developed/supporting behavior	Measuring success
<p><i>“the camp was a very different set of problems”</i></p> <p><i>“what we learned from math camp [was], more than so ... more so than, you know, [the] standard curriculum”; “You just have to ... and I think a little more, more creatively ...very different”</i></p> <p><i>“camp gave me more time to kind of work with the problem”; “kind of doodle around and think about things and it gave you the time to problem solve”</i></p> <p><i>“This camp has been the place that inspired me and motivated me to try, try, and try...that’s what all those problems sets are about ☺”</i></p>	<p>Camp fosters <b>creative thinking</b> and <b>persistence</b> by offering <b>challenging</b> non-standard <b>curriculum</b> and ample time to struggle with problems without any pressure</p> <p><b>[Material Resource]</b></p>	<p>Persistence, creative thinking, productive struggle.</p>	<p>Learning a new concept</p> <p>Deep understanding</p> <p>Enjoying problem solving</p>
<p><i>“after getting to know so many super intelligent and talented people at camp, I realize in so many ways they are just like me”</i></p> <p><i>“You open your eyes to, like, what people really know, ... There are people who are really good at programming. There are people who can, um, do their ... the Rubik's cubes in like a minute ... You're like, "Oh my gosh!", "People can actually do that?" Like ... You know, you do [get] exposed to a wide range of smart people. I think that's a really good thing. Like, you know, for people, when they grow up”</i></p> <p><i>“I appreciate wide range of thinking modes in my group”; “I did enjoying getting to know the uniqueness of my group members – their brilliance, inclinations, etc.”</i></p> <p><i>“...we were all winners for being explorers and thinkers and for persevering through difficult tasks. I found that lesson to be important during every step of my career and my journey in life.”</i></p>	<p>Peers who are just as knowledgeable or even better prepared/smarter than me</p> <p><b>[Relational Resource]</b>: Interaction with study group members/peers in class]</p> <p>Camp fosters aspects of growth mindset (<i>where everyone can be successful</i>)</p> <p><b>[Ideational Resource]</b></p>	<p>Was humbled;</p> <p>Confronted her fixed ability view</p> <p>Working hard and persisting in solving problems</p> <p>Learning from others</p> <p>Learning to appreciate diversity of skills in people.</p>	<p>Adapting to a view where anyone can be successful irrespective of their race/ethnicity/national origin</p> <p>Learning that hard-work, persistence, and collaboration lead to success</p>

Figure 25. Hima’s MLI during/post RSMC

Participant utterances	Characteristics/Practices of the Learning environment	Behavior developed/supporting behavior	Measuring success
<p><i>"[Mark] didn't make the camp, like, a very competitive environment...He made it more of, uh, you know, like, We're here to learn"</i></p> <p><i>"Dr. [Weitzman] made sure to remind us everyday that we were there to learn, not to see who came up with the solution the fastest"</i></p> <p><i>"we're, like, working in groups, we're just trying to, you know, develop that knowledge at our own pace"</i></p>	<p>Camp fostered a <b>non-competitive</b> and <b>collaborative</b> environment by teachers emphasizing and modeling this practice</p> <p><b>[Ideational and Relational Resources]</b></p>	<p>Learned to collaborate and not compete with peers</p>	<p>Forging collaborative relationships</p>
<p><i>"Our group is a very nice mix and I enjoyed work with my group mates"; "...by looking at others' method, I gained a little better insight into the problem"; "I enjoyed taking part in my group's struggle to prove the statement"; "We tend to explore a problem for a long duration...we got stuck on the Lagrange's theorem for nearly 3 hours"</i></p>	<p>Study Groups: dividing campers into study groups and assigning a counselor as a mentor with the expectation of working together and helping each other learn.</p> <p><b>[Material, Ideational and Relational Resources]</b></p>	<p><b>Bonding</b> with group mates through the process of doing some very challenging math together.</p> <p>Learning to get along with others, <b>learning through discourse</b> and appreciating <b>different perspectives</b></p>	<p>Forging positive and collaborative relationships with peers and learning.</p>
<p><i>"[Mark] he's definitely very positive... he's the type of...teacher with an attitude... if anybody can ever learn to do it, just ... you know, everybody should be able to do it and be wonderful."</i></p> <p><i>"you may feel like, This is really dumb, like, I have no idea how to do this basic thing. He's actually like, This is incredible! (laughing) You did a great job."</i></p> <p><i>"it just uplifts people"</i></p> <p><i>"teachers were very encouraging"</i></p> <p><i>"...encouraged me ... to explore and venture into uncharted territories and discover new ideas."</i></p>	<p>Teachers at RSMC build your confidence, offer encouragement, foster persistence, and create a positive and safe learning environment where it's okay to make mistakes.</p> <p><b>[Ideational and Relational Resource]</b></p>	<p>Persisting through challenging problems, taking risks and trying new things when solving a problem. Not being afraid of making mistakes.</p>	<p>Not being afraid of anything when learning, feeling confident</p> <p>Learning is a reward in itself.</p>

Figure 25, Continued. Hima's MLI during/post RSMC

Participant utterances	Characteristics/Practices of the Learning environment	Behavior developed/supporting behavior	Measuring success
<p><i>"I think it actually freed me from that kind of mentality, ... just ... you know, if you enjoy math, it's fine to enjoy it"; "it was the people I associated with and became best friends with that really helped me"; "I found a group of people with whom I was free to be myself." "it [camp] helped me grow tremendously as a person and served as a shelter during a time when I was trying to find my way in life"; "That feeling of acceptance gave me the confidence to reach far in life" "He[Mark] taught me to appreciate my own ways of thinking"; "I have had the freedom to explore new ideas, try new things..."; "it[camp] made me more flexible in terms of what... I would ... like, knowing ... There are <b>other fields</b> I can pursue ...And I can <b>use the same knowledge</b>"</i></p>	<p>RSMC provided a safe and collaborative environment of acceptance, to simply enjoy math, be yourself, encourage individual thinking, and explore different interests (math is a part of other fields too).</p> <p><b>[Ideational and Relational Resources]</b></p>	<p>Learned to just enjoy math, think for herself and be herself.</p> <p>Forming a connection with peers who end up being your best friends.</p> <p>Exploring new interests, developing confidence is trying something different</p>	<p>Enjoying math with friends, being herself, exploring different interests.</p> <p>Experiencing freedom to take charge of your life.</p>
<p><i>"I spent part of my day at the library browsing through magazines. This <b>made me feel real existence on a college campus.</b>"; "...what you expect in the future, like the structure learning environment in college ... it [gave] exposure to like what life would be [inaudible 00:26:40] you know, after high school..." "it's been an incredible summer ...how to design camp T-shirt and make Cool-aid, ...have fun Pow-wowing ... at the [City X] Museum of Art,... watch a musical on the hillside, sleep on a Ping-pong table,...stay up at [the ranch] ...this summer is packed with memories that years after, I shall recall with sweetness "</i></p>	<p>Weekend Trips and living on a college campus.</p> <p><b>[Material and Relational Resources]</b></p>	<p>Bonding with peers in a non-classroom setting by <b>sharing new experiences.</b></p> <p>Exposure to life on a college campus.</p> <p>Strengthening aspirations to go to college</p> <p>Getting to know others, making friends.</p>	<p>Getting exposure to the outside world</p> <p>Getting a feel for college life</p>
<p><b>MLI (A<sub>A</sub>/ A<sub>C</sub>) being developed:</b></p>	<p><i>Mathematics is a vast, challenging, and creative discipline. I can be successful in this field or any other field by being myself, persisting, working hard, creating collaborative relationships, learning for understanding, never forgetting the joy of thinking and discovery, and enjoying the process. Anyone can be successful at math by working hard.</i></p>		

Figure 25, Continued. Hima's MLI during/post RSMC

### **The shift in Hima's MLI**

Hima went from having a very narrow view of mathematics (*algebra, geometry & calculus; problems always having a fixed, structured, non-creative way of solving*) and what it means to be successful in it (*competing, solving lots of problems quickly, memorizing*) to a much broader and realistic view of what constitutes the realm of mathematics (*a creative discipline; applications of math in different fields*) and what does it mean to be successful in it (*learning from different perspectives, collaborating, enjoying the process of thinking and discovery, taking risks, persisting, developing internal understanding*). Hima developed a set of study skills and motivation to persist in doing math when it became challenging. She learned at camp how to collaborate with others and have fun with her friends while solving problems. She also learned to deal with frustrations of getting stuck on problems, failure, the fear and the discomfort that comes with exploring an uncharted territory, and discovering new ideas. She also experienced the joy of problem solving for the sake of it and not mastering these skills to compete in a contest. Experiencing internal understanding, sharing it with peers and teachers, and mentoring the new campers to develop their own problem-solving skills was very rewarding for her. Camp became a haven for her where she was accepted for who she was, did not feel ashamed for liking math, and enjoyed working on problems with like-minded peers. Furthermore, being in RSMC environment where she met a diverse group of peers who were just as knowledgeable as herself helped her break through a previously held notion about being naturally good at math just because she was from China. She went from having a fixed ability view (*where an innate ability dictates how good you are in math*) to a mindset where anyone can be good at math if they

persisted and worked hard towards true understanding. This is a powerful finding and has implications on creating and maintaining a diverse student body in RSMC or any other informal learning space.

### **Higher Education Trajectory upon leaving RSMC**

What experiences led this young immigrant girl from a modest financial background to become a successful physician? Did RSMC have any impact on the higher educational/career paths that Hima took? If so, what? To answer these questions, I explored the construct of SC in terms of the resources available to and accessed by the participant through social networks (e.g. parents, relatives, friends, acquaintances, peers, teachers, mentors, and organizations) before and after being a member of RSMC towards her status attainment (education/career) goals. This section describes the higher education/career trajectory that Hima envisioned for herself prior to RSMC experience and the shift that took place in this trajectory during RSMC. All the quotes that appear in this section are from the journals, camp evaluations, correspondence, survey, and the interview.

#### **From a pursuing what her parents wanted her to do to figuring out what she wanted to do**

In order to determine the impact of RSMC on Hima's SC and consequently on her higher education/career trajectory, I asked her to recall her career aspirations before coming to RSMC and describe if RSMC had any influence in realizing or changing those aspirations. The following figures show examples of utterances from her recent survey, interview, and past documents that lead me to conclude that before coming to RSMC, Hima didn't know what she wanted to do. Her parents wanted her to pursue computer

science or get a PhD in math because she was considered good in school mathematics. So, her plan was to do what her parents asked of her. Regarding colleges, she hadn't planned on applying to any selective schools. She would have been happy to get into any college. This is as far as she dreamed based on the resources she accessed in her immediate social capital such as her dad and her school counselors. However, RSMC disrupted this trajectory for Hima by encouraging her to figure out what really interested her, by respecting and supporting her choices, by expanding her social network and making available to her resources that would open up a world of opportunities, broaden her horizons, and give her the confidence to pursue her dreams.

Table 8  
*Hima's Pre-RSMC SC*

Before RSMC: education/career trajectory	Participant utterances	
Parents aspired for Hima to study computer science or math	<i>"I think my family had one set of ideas. (laughs)... my dad [inaudible 00:30:29] and he, uh, he was [like] get a PhD in math"</i>	<i>"...He[Dad] got a Master's in computer science, so that's his background... then, so, initially I thought I was going to do computer science ... Of course, they were very supportive... so my parents have not ... They're very single-minded..."</i>
Limited encouragement	<i>"I didn't really have, I would say, like, encouraging people around me"</i>	
Didn't know what she wanted	<i>"I don't think I even thought about college..."</i>	<i>"I never really thought, like, What do I want to do in college?"</i>
Planned to attend any college	<i>"I didn't even think about where I was going to college..."</i>	<i>"I probably would be like, Oh, I'll be happy to go to just, you know, any place... I didn't think about the future"</i>

Table 9  
Hima's Post-RSMC SC

During/Post RSMC: education/career trajectory	Participant utterances		
RSMC significantly improved my academic preparation by teaching me life and study skills	<p><i>"immerse myself in math and learning"</i></p> <p><i>"This camp has been the place that inspired me and motivated me to try, try, and try"</i></p>	<p><i>"taught me the value of perseverance and the joy of thinking and discovery"</i></p> <p><i>"I appreciate wide range of thinking modes in my group"</i></p>	<p><i>"helped developed patience with challenging things"</i></p> <p><i>"it does feel good to do something that I can't grasp right off hand"</i></p>
RSMC encouraged me try new things and explore my interests	<i>"confidence to try and think of new things/careers"</i>	<p><i>"I have had the freedom to explore new ideas, try new things..."</i></p> <p><i>"perhaps graph theory and chemistry is something I could consider"</i></p>	<i>"I yearn to enjoy everything[...]learning about latest breakthroughs in biochemistry...if possible I want to major/minor in International studies"</i>
RSMC was very supportive of all my choices	<i>"Dr. [Weitzman] really knew you as a person, so he was always, like, there to help you along."</i>	<i>"Whether it's college, the medical school ... At one point, I wanted to just teach math. (laughs) Just teach high school math .. He [Dr. Weitzman] was like, Yeah, well, I wrote you a recommendation too, so he was always just there to kind of support you and whatever crazy ideas you have."</i>	<i>"I definitely, um, you know, a lot, ...appreciate him [Dr. Weitzman] for doing that... he didn't judge you for pursuing careers that's outside math or...come back to math or whatever it is"</i>
RSMC expanded social capital	<p><i>"So [at camp] you actually had a lot of opportunities to kind of think about it,..., talk to other students about it... They're, like, all thinking about college."</i></p> <p><i>"seeing what other people did with their careers ... other people going to medical school and ... There was also the [inaudible 00:21:25] epidemic ... then that's how I got attracted to medicine"</i></p>	<p><i>"Dr. [Weitzman] was always good at writing recommendations. I think he really helped me"</i></p> <p><i>"I would say that the math camp definitely made, made those schools even a possibility (laughing) on my radar it definitely led to a lot of opportunities I would never have thought about... You know, like I couldn't have pursued medicine"</i></p>	<p><i>"...even for medical school, I think even Dr. [Weitzman] wrote one of the recommendation letters, so, like, there was always somebody who supported me..."</i></p> <p>Mark Weitzman wrote the following in Hima's Journal, 2000  <i>"Do set your sights high – I expect you to be very highly sought after by top schools!! (MIT, Cal-tech, Harvard, Stanford, UT)"</i></p>

Table 9 Continued

RSMC broadened horizons and gave confidence to pursue my dreams	<i>“I have had ...this ineffably grand freedom to expand my horizons”</i>  <i>“That feeling of acceptance gave me confidence to reach far in life”</i>	<i>“My present future of attending [University B] and feeling so excited about life would not have come by without my camp experience...the confidence I developed, the skills I learned...carried me far.”</i>	<i>“confidence to try and think of new things/careers”</i>  <i>“The daring spirit and critical thinking skills that I learned from math camp continue to help me on my journey to become a physician to...help those in need”</i>
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The quotes above illustrate that RSMC had a crucial impact on Hima’s higher education/career trajectory, aspirations, and the decisions she made regarding choosing a major and applying to some of the top-ranked institutions of higher learning. In this way, RSMC altered the course of Hima’s educational/career journey by providing her support and encouragement to figure out what she wanted to do in life and helping her to get into some of the selective and top ranked institutions of higher learning. We may note from the perspective of this participant how access to and use of embedded resources in RSMC enhanced Hima’s chances of attaining better statuses with respect to higher education and career related decisions.

### **RSMC characteristics/practices valued by the participant**

What practices and components of RSMC does Hima value and credit, if any? In this section I identify particular practices that Hima values and that led to the impact on her MLI and SC as discussed earlier. Hima mentions these practices/components either in her past documents or in her recent correspondence, survey, and interview. The following figure shows excerpts from Hima’s past data sources in which she mentions aspects of camp that she likes or appreciates.

RSMC Practices/Components Valued	Participant utterances	Data Source
Teaching practices ( <i>deep understanding, clear explanations, learning from different perspectives, persistence, life-skills</i> ) at RSMC	<p><i>"[Tony] is wonderful at getting everyone involved and helping me with questions"</i></p> <p><i>"I enjoy hearing about different approaches to the same problem"</i></p> <p><i>"[Edmund] is a wonderful teacher – through and clear in his explanations"</i></p> <p><i>"yep, it does feel good to do something that I can't grasp right off hand."</i></p> <p><i>"This camp has been the place that inspired me and motivated me to try, try, and try...that's what all those problems sets are about ☺"</i></p> <p><i>"immerse myself in math and learning"</i></p> <p><i>"[Mark], you have given me and so many other students the tools to carry [us] far in life"</i></p> <p><i>"Through this camp, I became aware of the inner strength inside me, and I'm very glad to have such a great opportunity. Thanks [Mark] ☺"</i></p>	Data Source: Journals, 1998, 2000, Camp evaluations, 2000, 2001
Camp Curriculum	<p><i>"I would much definitely say that the classes are fascinating"</i></p> <p><i>"Analysis needless to say is splendid – I'm always energetic in that class"</i></p> <p><i>"Learning to count the possible arrangements or selections when given a situation...who would have thought of the elegance of the inclusion-exclusion principle and the rook-polynomial method...I truly enjoy learning Combinatorics..."</i></p> <p><i>"I feel more acquainted with proofs now than before...This has been an extremely intense exercise of mind for me"</i></p>	Data Sources: Journals, 1998, 2000, Camp evaluations, 2000, 2001
Study groups ( <i>bonding, feeling accepted by peers, learning through discourse and collaboration</i> )	<p><i>"I do appreciate the wide-ranged thinking modes in my group."</i></p> <p><i>"I found a group of people with whom I was free to be myself."</i></p> <p><i>"Our group is a very nice mix and I enjoyed work with my group mates""...by looking at others' method, I gained a little better insight into the problem""I enjoyed taking part in my group's struggle to prove the statement""We tend to explore a problem for a long duration...we got stuck on the Lagrange's theorem for nearly 3 hours"</i></p>	Data Sources: Journals, 1998, 2000, Camp evaluation, 2001

Figure 26. RSMC components valued by Hima as noted in her past data sources

RSMC Practices/Components Valued	Participant utterances	Data Source
Camp Counselors ( <i>help received from her counselors as well as being a counselor herself</i> )	<p><i>"In problem session...[Kenny] [counselor] went over the ambiguous parts of the number theory class. That was helpful."</i></p> <p><i>"Here's a proof that our group toiled to come up with, but I do have to credit [Barry] [counselor] for the ideas and [Cynthia] [counselor] for the helpful suggestions."</i></p> <p><i>"It's been a pleasure coming back as a counselor and seeing a group of first years becoming better thinkers and better persons. Just to watch them learn and grow was very enriching."</i></p>	Data Source: Journals, 1998, 2000, Camp evaluation, 2001
Colloquia ( <i>Experiences exposing to STEM ideas. Female speakers in STEM mentioned</i> )	<p><i>"[Harriet's] colloquium was quite interesting and ...inspiring."</i></p> <p><i>"[Delores] covered some very interesting topics"</i></p> <p><i>"The speakers had wonderful ideas. [Harriet's] presentation was rather interesting...gave me some insight into her career."</i></p>	Data Source: Journal, 1998, Camp evaluation, 2000
Social aspects at RSMC ( <i>weekend trips, socializing with peers, exposure to life on a college campus</i> )	<p><i>"I spent part of my day at the library browsing through magazines. This made me feel real existence on a college campus."</i></p> <p><i>"it's been an incredible summer ...how to design camp T-shirt and make Cool-aid, ...have fun Pow-wow-ing ... at the [...] Museum of Art,... watch a musical on the hillside, sleep on a Ping-pong table,...stay up at [the ranch]...this summer is packed with memories that years after, I shall recall with sweetness "</i></p>	Data Sources: Journals, 1998, 2000, Camp evaluation, 2001

Figure 26, Continued. RSMC components valued by Hima as noted in her past data sources

When asked in the recent survey and interview about the practices/characteristics or elements of RSMC that Hima came to value, she identified the following – *support and encouragement from her professor and mentor – Mark Weitzman, her peers in the study groups, safe environment, teaching practices (such as time to explore the problems for deep understanding, emphasizing the process over the answer, not giving the answer*

*but letting you discover it yourself, persistence, life skills), camp curriculum, and social aspects such as weekend trips and exposure to life on a college campus* as most significant for her. Some of the same elements were echoed in her recent correspondence in addition to the practice of journaling.

Regarding RSMC the support and encouragement that she received from her mentor Mark Weitzman, Hima stated “Dr. [Weitzman’s] caring and unwavering support for me has been very important in helping me become the person I am today. It’s not often in a person’s lifetime that one comes across a teacher, a mentor, and an advocate who has been so influential and whose summer program has been so life changing.”

With respect to her peers in the study groups, Hima mentioned that “Being from an immigrant family...I had difficulty...finding acceptance...However, I found a second home at camp. I got to enjoy the summers with friends who also enjoyed solving math problems for fun and...who were always there for you. That feeling of acceptance gave me the confidence to reach far in life.” She appreciated the “usual study group things” such as “You did work and you played and you (laughs) ate a bunch of food,... , you do learn to work together. You also learn to have fun in the process.” Furthermore, Hima values the safe and collaborative environment that camp provided where she was “free to be [herself]” and was encouraged to “appreciate [her] own ways of thinking.”

Hima considers teaching practices of the camp to be one of the important components of RSMC. She appreciated how teachers would help the campers discover the solutions to the problems themselves instead of giving them the answers. She mentioned in her interview that “Analysis class... [Tony] ... he would try to lead you along and try to think of a solution.” Similarly, she valued how Mark emphasized the

journey of solving the problem as more important than “chasing answers”. Hima recalls that the teachers at RSMC taught her not to get “discouraged as fast” when working on challenging problems, “take [her] time” with a few problems instead of “getting a lot of problems” done, reminded her of “the beauty inherent in the thinking process itself, encouraged her to “explore and venture into uncharted territories and discover new ideas”, and taught her “the value of perseverance and the joy of thinking and discovery”. Furthermore, she appreciated camp’s “non-standard curriculum” such as “theoretical math” which is the type of math that one would need in college. In this way camp curriculum provided her with a more “realistic understanding” of mathematics. It is a “different set of problems” that requires you to “think” and “think more creatively.”

Hima also values the social aspects of the camp. In her interview she stated “trips were fun too, you know. A lot of us probably never done rafting, never did a lot of things ... they gave us exposure to the outside world...”. Hima certainly appreciated the glimpse she got from camp to the kind of life she might have in college. She stated in her interview “...what you expect in the future, like the structure learning environment in college and things like that. I think it [gave] exposure to like what life would be [inaudible 00:26:40] you know, after high school... so, yeah ... I think that in that aspect was pretty good, you know.”

Although she didn’t recall it her in interview, but in a recent correspondence, Hima had written how important the practice of journaling was to her as a camper:

“I remember how he [Mark] used to collect them [journals] in a big pile at the end of each week and read them on our weekend trips. It was not just a formality; he actually took the time to read those journals and comment in them, and if needed, talk to us

individually about the problems we faced. I don't know how others thought about it, but I definitely appreciated the foresight he had in creating that journal. That line of communication was important because I sure needed a way to convey frustration without the awkwardness of direct speech. It was nice knowing that at the end of the day, somebody cared about what you had to say about the world around you.”

The above illustrates how valuable the practice of journaling was to Hima. It was an important step in building a strong and meaningful relationship with her mentor. This practice affords a necessary and great relational resource to RSMC students and the camp director to nurture the campers' learning identities. Journaling serves as a student support activity through which the students can communicate any issues they may be experiencing directly to the RSMC director as can be seen in the case of Hima.

### **Summary of RSMC practices valued**

Some of the same practices that were valued by Hima when she was a high school student attending RSMC were also valued by her in her recent retrospective interview, survey, and correspondence. The figure below summarizes Hima's valued practices and components of RSMC from the past and the present. The highlighted cells indicate the common ones. These are elements of RSMC that led to the impact on Hima's MLI and higher education/career trajectory overtime.

Table 10

*Summary of RSMC practices/components valued by Hima*

RSMC Practices/components valued in the Past (while attending camp during high school)	RSMC Practices/components valued in the Present (in retrospect)
Teaching practices ( <i>deep understanding, clear explanations, learning from different perspectives, persistence, life-skills</i> ) at RSMC	Teaching practices ( <i>deep understanding, process centered, discovery based or risk taking, persistence, life-skills</i> ) at RSMC
Camp counselors ( <i>help received from her counselors as well as being a counselor herself</i> )	Mentorship from the camp director at RSMC ( <i>provides help, support, encouragement, an outlet of communication</i> )
Colloquia ( <i>Experiences exposing to STEM ideas. Female speakers in STEM mentioned</i> )	Journaling
Study groups ( <i>bonding, feeling accepted by peers, learning through discourse and collaboration, having fun in the process</i> )	Study groups ( <i>bonding, feeling accepted by peers, learning through discourse and collaboration, having fun in the process</i> )
Camp curriculum ( <i>challenging, combinatorics, graph theory, analysis, number theory</i> )	Camp curriculum ( <i>challenging, different set of problems, theoretical math, non-standard, number theory</i> )
Social aspects at RSMC ( <i>weekend trips – trying new things, socializing with peers, exposure to life on a college campus</i> )	Social aspects at RSMC ( <i>weekend trips – trying new things, exposure to the outside world, exposure to life on a college campus</i> )
Safe and collaborative environment of acceptance <i>that encourages independent thinking, and values individual choices</i>	Safe and collaborative environment of acceptance <i>that encourages independent thinking, and values individual choices</i>

### Case Summary

According to Hima, RSMC not only played a significant role in changing her perceptions about learning math and herself as a learner of math i.e. MLI development, but the camp was also instrumental in her finding acceptance in the US after moving from China during the formative years of her life. Hima went from having a very narrow, rote, and non-creative view of mathematics and what counts as success to a much broader and realistic view of what constitutes the realm of mathematics and what it means to be successful in it. Hima developed a set of study skills and motivation to persist in doing math when it became challenging. At camp she learned how to collaborate with others

and have fun with her friends in the process of learning. She also learned to find joy in the uncertainty that comes with exploring an uncharted territory and discovering new ideas. Experiencing internal understanding, sharing it with peers and teachers, and mentoring the new campers to develop their own problem-solving skills was very rewarding for her. Furthermore, being in the RSMC environment, where she met a diverse group of peers who were just as knowledgeable as herself, helped her break through a previously held notion about being naturally good at math just because she was from China. In this way, she confronted her fixed ability mindset and the national origin storyline. This may suggest that she came to the conclusion that everyone irrespective of his or her background can learn math through hard work. The company of like-minded peers, a community that fosters a growth mindset in a safe and collaborative learning environment, and a nurturing and supportive mentor made RSMC a “transformative experience” for Hima. In Hima’s own words we may note the significance of RSMC for her - “In many ways, math camp became more than just an educational experience; it became a life-changing experience.”

Before coming to RSMC Hima didn’t know what *she wanted* to pursue as a career. Her parents wanted her to pursue computer science or math because she was considered good in school mathematics. Furthermore, Hima had no plans to apply to any of the top ranking, selective schools for higher education. However, RSMC disrupted this trajectory for Hima by encouraging her to figure out what really interested her, by respecting and supporting her choices, by expanding her social network and making available to her resources that opened up a world of opportunities, and giving her the confidence to pursue *her* dreams. Hima ended up applying to top-ranked universities such

as MIT, Harvard, Rice, and Princeton among others. She ended up choosing University B to further her undergraduate education in an area that interested her, biology and medicine. Upon graduating from University B, Hima went to medical school and earned an MD from one of the top-ranked schools of Medicine and a Masters degree in Epidemiology from an equally renowned university. She credits the embedded resources in RSMC for her higher education and career related decisions as she notes “All of these endeavors were made possible because of Dr. [Weitzman’s] unwavering support and encouragement and because of the way that camp opened my eyes to the many opportunities out there...” In this way, RSMC altered the course of Hima’s educational/career journey.

The particular practices and components that Hima came to value over time as mentioned either in her past data (journals, evaluations) or in her recent, correspondence, survey and interview include

- Teaching practices such as emphasis on deep understanding and persistence, valuing the process more than the answer, clear explanations provided by teachers, learning from different perspectives, and taking risks to discover new ideas.
- Study groups that encourage bonding, learning through discourse and collaboration among peers, enjoying the process of learning with friends.
- Camp curriculum that is challenging, non-standard and includes topics such as number theory, Combinatorics to which students aren’t normally exposed to in most high schools.

- Journaling that provides a support structure for students to communicate any frustrations or issues they may be experiencing directly to the RSMC director in a written and reflective manner.
- Mentorship from the camp director at RSMC. A practice that provides help, support, encouragement, and guidance to new campers who may initially find it difficult to connect with peers or counselors.
- Counselors who serve as an aid to help campers with their camp course work and an opportunity for returning campers to become counselors themselves in order to mentor a new cohort of campers.
- Camp colloquia talks providing experiences, where students are exposed to STEM ideas and research by speakers from different STEM fields. Hima took particular note of female speakers in STEM and mentioned how much she enjoyed these talks at the colloquia in her camp evaluations.
- Social aspects such as weekend trips that provide opportunities to bond with peers, try new things, and get an exposure to the outside world. While living and studying on a college campus instills independence in campers and affords them an opportunity to envision a life in college.
- Sense of a safe and collaborative community that provides help and support when needed, encourages independent thinking, and values individual choices.

### **Case 3: Mira**

I first met Mira over Skype for our first interview. Mira is a jovial Hispanic woman in her early thirties, with a confident personality. Mira grew up in an urban area that was predominantly Hispanic from working class families. Her father was a construction worker and her mother worked as a house cleaner. Both her parents only speak Spanish. She is a first generation college student in her family. She started out as mathematics major at one of the top-ranked schools in the US, we shall refer to it as University C, but later switched to another major. She graduated with a B.A. in Comparative Literature and Political Science and a Masters in Education from University C. She wanted to become a math teacher just like the ones from RSMC especially like Mark Weitzman, the camp director, and help students who struggle with math. She recalled her experience as a counselor at camp (where she helped new campers with math and motivated several students from underrepresented backgrounds to persevere) as having a significant impact on her wanting to pursue a career in teaching math. Owing to her hard work and determination, Mira was accepted at one of the leading universities in the nation as a math major to fulfill her dream. Unfortunately, she felt that she was marginalized from the field in college. Mira however did not give up on her education or drop out of college. She decided to switch her field of study to her secondary interest and continued on with her goal of becoming an educator. She is a successful high school teacher of English Literature.

#### **Trajectories of identities: MLI co-construction and shifts**

In this section I will describe the story of Mira, a young Hispanic teacher, and her experiences at an informal math summer program - RSMC during her high school and

undergraduate years. In order to determine the identity trajectory that RSMC helped create for Mira, I will first explore the path she was already on prior to coming to RSMC. This will entail describing her perceptions about learning math and herself as a learner of math in her high-school classroom. Next, I will describe the shift in the MLI trajectory that RSMC helped create for Mira.

### **Pre-MLI: What constitutes learning in Math?**

In order to determine the impact of RSMC on Mira's MLI, I asked her to recall her beliefs about learning and doing math prior to coming to camp as well as describe her perceptions of herself as a student of mathematics. We shall call this Mira's Pre-MLI. The retrospective interview is the primary data source for determining her Pre-MLI.

The following figure shows an example of utterances from her interviews that lead me to conclude that for Mira prior to RSMC learning math meant memorizing what the teacher said and being able to regurgitate it during exams, while doing math meant being able to quickly solve problems that always had one exact answer. Math itself was seen by her as something that was just a bunch of numbers with no real applications.

<i>Perceptions about learning/doing math before RSMC</i>	<i>Participants' utterances</i>		
Solving problems (that had one right way to answer) quickly and getting them right. The answer was more important than the process.	“solving problems as quickly as possible” “one right way to approach a problem”	“It was about quickness”	“Just get all the problems right” “It wasn't about deep understanding”
Memorizing rules and procedures without any conceptual understanding	“I had to remember the theorems, and the rules”	“I had to remember a negative times a negative is equals a positive... Zero times any number equals zero... so it's just a matter of remembering what the rules were”	“I didn't have a big picture of the concepts. I didn't fully understand how things connected”
Math is just equations that need solving or graphing.	“All I thought was equations that I needed to solve... Things that I needed to graph”		
Teacher tells what to do	“It was very teacher directed, teacher centered”	“everything I was learning in school is very rote”	
<b>Emerging theme</b>	Memorizing rules and procedures (given by the teacher) to find the right answer quickly. Math itself is just some equations that needed to be solved or graphed and required one right way to approach.		

Figure 27. Mira's perceptions about learning/doing math before RSMC

### **Pre-MLI: Am I good at math? (Self-perceptions about being a learner of mathematics)**

When I asked Mira to describe her self-perceptions as a student of mathematics prior to RSMC, she said she considered herself “a star math student”. This perception was based on her understanding of what math was, her being allowed to take Algebra early, her grades, and the discourses about being “good” at math that were prevalent at her school. These discourses equated competence with memorization of procedures,

speed, and high scores on tests. The students who were considered “good” at math always did what the teacher said, tended to solve problems quickly, and maintained good scores on tests. Mira also recalled that “it didn't take a lot from people... academically...” to be successful at her high school, implying that the curriculum at her school was not very challenging. The school didn't offer any AP courses either. Teachers generally didn't demand very much from the students. They expected students to memorize rules, complete the assigned homework, and get good scores on tests. The learning environment was rote, “very...teacher-centered” and there was “a lot of teaching to the test”. This meant being “good” at math required getting good grades on tests by paying attention and taking notes in class, memorizing, doing what is expected, and earning teachers' praise. All of which Mira was able to do successfully. The figure below shows the practices of Mira's high school learning environment, the behavior that they developed in her, and how she came to measure her success in such a community. These findings are supported by Mira's quotes from her interview.

Participant utterances	Characteristics/Practices of the Learning environment	Behavior developed	Measuring success for the behavior
“It was very teacher directed, teacher centered” “a lot of note taking, homework at home, and then you would come to school and you would check it” “I had to remember the theorems, and the rules” “everything I was learning in school is very rote” “Just get all the problems right”	Listen to the teacher, take notes, do your homework, and solve the problems that are given by the teacher correctly.	To memorize rules given by the teacher, and answer questions correctly.	Finding/ getting the right answer
“it was all about who is quicker at solving the equations” “solving problems as quickly as possible” “It wasn't about deep understanding”	Emphasis on speed when solving problems.	Solve the problems that are given to you quickly. Speed is more important than understanding.	Being the fastest student in class
“my school didn't offer APs.” “I went to ... How do you say this. Not the best high school. My freshman class I think started with about 600 students. Four years later 214 of us graduated.” “It didn't take a lot from people... academically... Unfortunately”	Having low expectations of the students Curriculum that is not very challenging. Unmotivated peers.	Meeting the low expectations of the teachers and thinking you are good if you met these expectations.	Doing what was assigned in the given time frame and graduating.
“There was a lot of teaching to the test” “It was a TASS then... It was a big deal when your scores came out.” “The school made a big deal if you were proficient. The school wanted to get that label.”	Emphasis on standardized testing	Learning how to perform well on the test.	Getting a score on the test.

Figure 28. Mira’s MLI (self-perceptions as a learner) before RSMC

Participant utterances	Characteristics/Practices of the Learning environment	Behavior developed	Measuring success for the behavior
<p>“I had to remember the theorems, and the rules”</p> <p>“... so it's just a matter of remembering what the rules were”</p> <p>“Just get all the problems right”</p> <p>“It wasn't about deep understanding”</p> <p>“everything I was learning in school is very rote”</p>	<p>Memorizing rules and procedures without any conceptual understanding to get the right answer</p>	<p>Figuring out how to memorize rules and theorems for the test</p>	<p>Getting right answer/good grades</p>
<p>“I never thought of myself as exceptionally bright in any way until about 8th grade. When I was allowed to take algebra 1 at the high school, and all the other kids were taking regular math class at the middle school.”</p> <p>“I felt smart in high school”</p> <p>“I felt like I was bright I guess, and it happened to be in math.”</p> <p>“Like I thought according to the way I was performing in my high school, and according to whatever my teachers told me... I was a star math student”</p>	<p>Being good at math means being ahead of all the peers by paying attention to the teacher and being allowed to take Algebra in 8<sup>th</sup> grade.</p> <p>Being good at math meant meeting your teachers' expectations and earning their praise.</p>	<p>Attributing her successes in math to being allowed to take Algebra in 8<sup>th</sup> grade ahead of all her peers, getting good grades, meeting her teachers' not very demanding expectations, and earning their praise.</p>	<p>Getting the right answer/good grades</p> <p>Teachers' praise</p>
<p><b>MLI (A<sub>A</sub>/A<sub>C</sub>) being developed:</b></p>	<p><i>I am good at math because I am allowed to take Algebra early ahead of my peers, get good grades by paying attention and taking notes in class, memorizing, and doing what is expected of me, I am good at completing the assigned problems quickly, getting the right answer, and earning my teachers' praise.</i></p>		

Figure 28, Continued. Mira's MLI (self-perceptions as a learner) before RSMC

The data suggests that Mira developed a learning identity to succeed in the practices that she encountered at her high school learning environment. These practices as noted above seem to be teacher centered, created a rote learning environment, and tended to equate competence in math with memorizing procedures, speed, and high test-scores.

### **Pre-MLI: Subscribing to racial, class, and/or gender ‘storylines’ in the context of learning math**

The following remarks about gender, class or ethnicity during our interview portion of pre-MLI and from her past camp essay lead me to conclude that Mira was trying to say that she is good at math despite all the gender, class, and ethnicity constraints of her situation. Therefore, she must be an exception to what is considered the norm within her community.

Narratives of gender/ethnicity/class
<p>“My mum cleans houses for a living.”</p> <p>“I, personally, come from a lower middle class family and attended a very poor and under-funded high school in [City X]”</p> <p>“My high school was 97% Latino”</p> <p>“You were tracked mostly by how many generations you'd been in the US. The kids who were in the honors classes, typically kids whose parents had also been in the US... In that sense I was in the minority because my parents were born in Mexico.”</p> <p>“my school didn't offer APs.”</p> <p>“I went to ... How do you say this. Not the best high school. My freshman class I think started with about 600 students. Four years later 214 of us graduated.”</p> <p>“I didn't have as many resources”</p> <p>“I never thought of myself as exceptionally bright in any way until about 8th grade. When I was allowed to take algebra”</p> <p>“I thought oh, maybe I'm good at something academically”</p> <p>“I felt like I was bright I guess...”</p>
<p><b>Emerging Theme [MLI (A<sub>AA</sub>/ A<sub>AC</sub>) being developed]:</b> <i>I am good at math despite being a Hispanic female from a low-income family whose parents were born in Mexico and who attended a high school for the underprivileged. It is not the norm for someone like me to be good at math, so I must be an exception.</i></p>

Figure 29. Mira’s MLI (narratives of gender/ethnicity/class) before RSMC

### Post-MLI: After the culture shock: moving onwards and upwards

The findings in this section illustrate how RSMC helped create an inbound math identity trajectory for Mira by affording her material, relational, and ideational identity resources (Nasir & Cooks, 2009) throughout her stay. I will show how over the course of her affiliation with RSMC, Mira became more connected to the practice of mathematics and developed a broader and holistic learning identity in the context of math in particular and education in general. Mira's retrospective accounts in her interview, a recent survey, and her handwritten documents (e.g. journals, camp essays, and camp evaluations) from when she was a camper and counselor at RSMC are used as data sources to help tell her story.

### First year at RSMC - challenges and struggles

The comments below from Mira's camp evaluation from 1998 and my recent interview with her illustrate the challenges Mira faced during her first year at camp.

Participant utterances	Data sources
<i>"We had had a packet that we needed to complete... I think one or two problems in there that I could complete"</i> <i>"Everybody went over their answers, because they had done everything. They obviously understood every single thing on there..."</i> <i>"I just didn't know what to do. I remember to [inaudible 00:14:40] like I have no idea. I don't know what you're saying"</i> <i>"I was very uncomfortable, and my counselor ... I don't even remember her name. I blocked her out. She was from MIT. I don't know what she knew what to do with me, because I started acting out."</i> <i>"They had to have a meeting with me to talk about my behavior"</i> <i>"This environment brought out that side of me, because I just didn't know what to do."</i> <i>"There's not one right way to approach a problem... whereas in high school it was"</i> <i>"It's really about the bigger ideas, and about becoming a critical thinker"</i> <i>"My group just blazing through the problems"</i> <i>"It [Mathematica] was a little too advanced for me and I felt that I didn't even have the basics of Mathematica down."</i> <i>"I couldn't follow the explanations on recurrence relations"</i> <i>"I was lost"</i> <i>"The problems that were given...was more than a hefty task."</i> <i>"It became obvious to me that I was not at a level that I thought that I was"</i>	Interview, camp evaluation, 1998

Figure 30. Mira's first year challenges at RSMC

From the figure above we may note that during the first year at camp Mira felt lost, confused, overwhelmed, frustrated, and intimidated. As a result, she even started acting as she recalled, “I don't know what she [counselor] knew what to do with me, because I started acting out. [...] They had to have a meeting with me to talk about my behavior.” The material in her camp courses such as Mathematica was quite challenging and new to her. Furthermore, working with problems that required critical thinking, understanding bigger ideas, and not having one fixed structure that Mira was used to at her high school was a new experience for her when it came to learning math. In the previous section we noted that Mira seemed to have a positive attitude about her proficiency in math. But what counted as success and being good at math in her high school is revealed in her conception of learning/doing math - *memorizing rules, getting the answer using one fixed method, and being fast*. This very view of what constituted math and learning was being shaken by the practices of her new learning environment at RSMC. Furthermore, she found herself in the company of peers who were better prepared and more knowledgeable than her, which was also a new experience for her. It was difficult for Mira to stop seeing math as just a bunch of equations that have one right method to approach and that needed to be solved quickly. She had to figure out a way to collaborate with her peers and take her time to understand the problems. The counselor Mira was paired with was not much help to her. As Mira recalls “my counselor ... I don't even remember her name. I blocked her out [...] I don't know what she knew what to do with me [...] I guess the way that I was asking for help wasn't conducive to actually getting help from my counselor. I think I was being a little bit rude, and so it went poorly.” The first year at camp was not a smooth ride for Mira and she almost quit the

program. However, Mark, the camp director, would not give up on Mira. He decided to invite Mira's high school teacher to have a meeting together with him about the issues Mira was facing. Mira recalls "After the meeting with [Mark], and my teacher was there too, Mr. [Leonard]. I committed to trying harder." Mark then invited Mira to come back next year and as she recalled in the interview, her "second year was phenomenal."

How did Mira adapt to this new learning environment at camp during her second year? Mira was carefully paired with a compatible counselor, Anna. In her camp evaluation and in our recent interview, Mira describes the crucial role that Anna played during the second year at camp. The quote below is taken from Mira's camp evaluation from 1998.

Anna was an awesome counselor. She knew how to explain things very clearly and always gave helpful hints. I think she was the best counselor at this camp and I am very grateful that she was my counselor. I liked that she wasn't uptight...She knew to make you think deeply about the problems and always had a word of praise when you accomplished something.

The above illustrates that Anna helped Mira construct a different way of learning mathematics more conducive to the camp and provided the necessary support structure to enhance Mira's learning. Mira recalls in her interview "The counselor in my second year was amazing. She was a Harvard kid... She was super patient." Furthermore, Mark also checked on Mira's progress often. She recalled in her interview, "I got a lot of support. I remember [Mark] would grade some of my problems sets. He would draw little bunnies...[or] Turtles right", and suddenly I felt good [...] Like I was 1 of 70 kids, and he was really invested in what I was doing." Mira's camp teachers also provided the

necessary support structure by checking in on her group. She writes in her camp evaluation “[Edmund] is a very good teacher...[Tony] was also a great teacher and, like [Edmund], I liked the fact that they came around to our rooms during study session and offered to help.” Furthermore, Mira by this time had learned how to collaborate with her group mates and seek help. She notes in her journal “...my group was great. Whenever I got stuck on a problem, there was always someone to ask for help even if [Anna] wasn’t there.” Similarly, in her recent interview Mira recalled “my experience in the second year there made me feel really valued ...My entire group was my resource. My counselor was phenomenal. I could go to [Mark], and ask questions about the problem set.” The entire RSMC community (teachers, counselor, and group members) was helping support Mira and shaping her math learning identity.

### **Experiencing RSMC – taking up the identity resources**

In the figure below I will argue that the three core identity resources as described in Nasir and Cooks (2009) were made available by RSMC (through its various components) and taken up by the participant. Note, that the availability of and the value of these resources comes from the participant herself. The figure includes Mira’s comments from past and present data sources that illustrate how her pre-MLI was interrupted and shifted on a different trajectory with a new and more profound understanding of herself as a learner and of mathematics as a discipline. This shift happened through the practices and characteristics that Mira encountered at RSMC and through her interaction with the practices. The data sources from which Mira’s quotes are used in the figure include - past data (camp essay, 2000; evaluations, 1998, 2001; journals, 2000, 2002) and present data (survey and interview).

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>Camp fosters <b>critical thinking, deep understanding</b> and <b>persistence</b> by offering a <b>interesting/challenging curriculum</b>, <b>ample time to struggle</b> with problems without any pressure and allowing students to <b>work at their own pace</b> in a non-competitive environment.</p> <p><b>[Material Resource; Ideational Resource]</b></p> <p><i>“It’s really about the bigger ideas, and about becoming a critical thinker. There’s not one right way to approach a problem”</i></p> <p><i>“I enjoyed the classes and found them interesting...Combinatorics I found extremely interesting.”</i></p> <p><i>“The best thing I liked...was that you were allowed to work at your own pace”</i></p>	<p>Learning for understanding, Persistence, critical thinking, productive struggle, enjoying the process of learning math.</p> <p><i>“There was nothing to feel bad about if you were in a different problem set or if you had done less proofs than anybody else”</i></p> <p><i>“taught me to look at math more carefully and not to rush through things”</i></p> <p><i>“it taught me that things can take time to learn, and that’s okay”</i></p>	<p>Appreciating and understanding what constitutes math</p> <p>Deep understanding</p> <p>Enjoying problem solving</p> <p><i>“I understood that Math was much more complex than I originally gave it credit for”</i></p> <p><i>“This camp has made me appreciate and enjoy math more that I ever thought I would.”</i></p>
<p>Pairing up campers with counselors. <b>[Relational Resource]</b></p> <p><i>“[Anna] was an awesome counselor. She knew how to explain things very clearly and always gave helpful hints. I think she was the best counselor at this camp and I am very grateful that she was my counselor. I liked that she wasn’t uptight...She knew to make you think deeply about the problems and always had a word of praise when you accomplished something.”</i></p> <p><i>“I remember it was the first time I heard of all these schools. You know he liked to ... [Mark] picked the counselors from like Carlton, and UT.”</i></p>	<p>Seeing counselor as a role-model, mentor, and taking up the offered support to improve learning</p> <p><i>“My interactions with counselors who were supportive in pushing my learning taught me the importance of having educators who had high standards, but provided a supportive environment”</i></p> <p><i>“I am able to take with me something new and valuable that I’ve learned here...and apply it to my normal life outside of math camp, helping me to become that much of a better person”</i></p>	<p>Building positive relationships</p> <p>Understanding how to learn math in different ways</p> <p>Finding a mentor and support structure</p> <p>Became a counselor at RSMC later to help new campers</p> <p>Carried her experience of learning how to form positive relationships to her life outside of camp</p>

Figure 31. Mira’s MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>Camp invites former campers to be counselors to the new cohort of campers <b>[Ideational Resource. Relational Resource]</b>  Mark, camp director, writes in Mira's counselor journals the following comments:</p> <p><i>"[Mira] you are doing an amazing job...No counselor I've ever had has done better at getting the most from each student, and them all develop together! You would be a fantastic teacher (or whatever else you'd [like to] do"</i></p> <p><i>"[Mira] not only are you wonderful with your own group, but you are learning to take charge and help other counselors. I'm so happy to see you growing, and everyone at camp respects you for your hard work and commitment!"</i></p>	<p>Helping others and giving back to the community</p> <p>Mentoring new campers</p> <p>Solidifying her career aspiration to become a math teacher.</p> <p>Recognizing the importance of having a diverse group of students and counselors and the message that sends.</p> <p><i>"I thought he [Mark] was being really strategic in the counselors that he was picking. Like my two years as a head counselor it was myself and a guy called [Jamal Nelson]. We both had similar backgrounds. He's Black, and I'm Latino... I think it's huge."</i></p>	<p>Helping others is a reward</p> <p>Being able to help students from diverse backgrounds</p> <p><i>"Interacting with students when I became a counselor myself also solidified my decision to teach. I was able to help students who entered at various skill levels and I liked the challenge in that."</i></p> <p><i>"I was a good counselor because I could connect with people"</i></p>
<p>Camp fosters aspects of growth mindset (where everyone can be successful) <b>[Ideational Resource]</b>  <i>"What It means to add value to something regardless of your knowledge set in math"</i></p> <p><i>"being able to succeed still there regardless of my background"</i></p> <p><i>"Like if you have the right resources, and the right support you're going to be fine"</i></p>	<p>Everyone has something unique to offer.</p> <p>Working hard and persisting in solving problems</p> <p>Learning to appreciate diversity of skills in herself and other people.</p> <p><i>"That you can offer something regardless of the background that you have, and then that influences who you become"</i></p>	<p>Adapting to a view where anyone can be successful irrespective of their race/ethnicity/class</p> <p>Learning that hard-work, persistence, and collaboration lead to success</p> <p><i>"It wasn't like I thought I had some innate ability that other students, that my peers didn't have... I just thought I just work[ed] harder"</i></p>

Figure 31, Continued. Mira's MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>Camp invites former campers to be counselors to the new cohort of campers <b>[Ideational Resource. Relational Resource]</b>  Mark, camp director, writes in Mira's counselor journals the following comments:</p> <p><i>"[Mira] you are doing an amazing job...No counselor I've ever had has done better at getting the most from each student, and them all develop together! You would be a fantastic teacher (or whatever else you'd [like to] do"</i></p> <p><i>"[Mira] not only are you wonderful with your own group, but you are learning to take charge and help other counselors. I'm so happy to see you growing, and everyone at camp respects you for your hard work and commitment!"</i></p>	<p>Helping others and giving back to the community</p> <p>Mentoring new campers</p> <p>Solidifying her career aspiration to become a math teacher.</p> <p>Recognizing the importance of having a diverse group of students and counselors and the message that sends.</p> <p><i>"I thought he [Mark] was being really strategic in the counselors that he was picking. Like my two years as a head counselor it was myself and a guy called [Jamal Nelson]. We both had similar backgrounds. He's Black, and I'm Latino... I think it's huge."</i></p>	<p>Helping others is a reward</p> <p>Being able to help students from diverse backgrounds</p> <p><i>"Interacting with students when I became a counselor myself also solidified my decision to teach. I was able to help students who entered at various skill levels and I liked the challenge in that."</i></p> <p><i>"I was a good counselor because I could connect with people"</i></p>
<p>Camp fosters aspects of growth mindset (where everyone can be successful) <b>[Ideational Resource]</b>  <i>"What It means to add value to something regardless of your knowledge set in math"</i></p> <p><i>"being able to succeed still there regardless of my background"</i></p> <p><i>"Like if you have the right resources, and the right support you're going to be fine"</i></p>	<p>Everyone has something unique to offer.</p> <p>Working hard and persisting in solving problems</p> <p>Learning to appreciate diversity of skills in herself and other people.</p> <p><i>"That you can offer something regardless of the background that you have, and then that influences who you become"</i></p>	<p>Adapting to a view where anyone can be successful irrespective of their race/ethnicity/class</p> <p>Learning that hard-work, persistence, and collaboration lead to success</p> <p><i>"It wasn't like I thought I had some innate ability that other students, that my peers didn't have... I just thought I just work[ed] harder"</i></p>

Figure 31, Continued. Mira's MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>Study Groups: dividing campers into study groups and assigning a counselor as a mentor with the expectation of working together and helping each other learn</p> <p><b>[Material, Ideational and Relational Resources]</b></p> <p><i>“That you can offer something regardless of the background that you have, and then that influences who you become”</i></p> <p><i>“...my group was great. Whenever I got stuck on a problem, there was always someone to ask for help”</i></p> <p><i>“The best part were the group study at night 6 to 10.”</i></p>	<p><b>Learning can be student directed</b>  <b>Peers</b> can be a resource for learning  <b>Bonding</b> with group mates through the process of doing some very challenging math together.</p> <p>Learning to get along with a diverse group of peers, <b>learning through discourse</b> and appreciating <b>diverse perspectives, everyone has something to offer</b> when learning  <i>“The group in the evening I think was huge for me. It taught me about how learning could be student directed.”</i>  <i>“It also taught me about how there are more resources than just the teacher, and what it is to mean to take advantage of those resources”</i></p>	<p>Forging positive and collaborative relationships with peers and learning.</p> <p><i>“This is my third year attending the [Riverside] Summer Math Camp and it never ceases to amaze me how incredible the people are here”</i></p> <p><i>“My entire group was my resource”</i></p> <p><i>“This camp...exposed me to an environment where I was given the opportunity to learn, not only at an academic level, but also on a level that would improve my people skills.”</i></p>
<p>Teachers at RSMC are invested in your learning, provide support, build your confidence, offer encouragement, foster deep understanding, persistence, and create a positive and safe learning environment where it’s okay to learn at your own pace.</p> <p><b>[Ideational and Relational Resource]</b>  <i>“I got a lot of support. I remember [Mark] would grade some of my problems sets. He would draw little bunnies...[or] Turtles right”, and suddenly I felt good”</i></p> <p><i>“The availability of the professors, and [Mark] in particular. Like just that investment in my learning. Like I was 1 of 70 kids, and he was really invested in what I was doing”</i></p> <p><i>“[Edmund] is a very good teacher...[Tony] was also a great teacher and, like [Edmund], I liked the fact that they came around to our rooms during study session and offered to help.”</i></p>	<p>Learning for deep understanding, persisting through challenging problems, taking the time to productively struggle with the problems.</p> <p><i>“it taught me that things can take time to learn, and that's okay.”</i></p> <p><i>“It taught me about the importance of teacher as coach, as opposed to teacher as the giver of all information”</i></p> <p><i>“My teachers and my counselor have taught me...it is always better to take your time and truly understand a proof or problem and only get a few done than to rush through them and not really understand what has happened.”</i></p>	<p>Learning is a reward in itself.</p>

Figure 31, Continued. Mira’s MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>RSMC provided a diverse, safe and collaborative environment of acceptance and mutual respect to learn and enjoy by connecting with people from diverse backgrounds.</p> <p><b>[Ideational and Relational Resources]</b></p> <p><i>“The people attend this camp come from a variety of backgrounds, having different socio-economic situations as well as ethnic backgrounds and beliefs, yet anybody, having only the desire to try, has the ability to fit in and be accepted for who they are”</i></p>	<p>Forming a connection with peers from diverse backgrounds; Learned to just enjoy math and be herself.; Feeling accepted by a diverse community for who she was and learning to accept others</p> <p><i>“the fact that I feel so positively about it[camp], and I am female, and I am Latino. I think it speaks to the impact that the camp can have. Specifically, because it's not just ... What do you call it. It wasn't just lip service. It was I [Mark] want to figure out what it means to serve a different population, than the one that traditionally succeeds in math.. ... I mean go [Mark]! When I get rich I will give him a lot of money.”</i></p>	<p>Enjoying math with friends, being herself Appreciating diversity.</p> <p><i>“This camp has made me appreciate and enjoy math more than I ever thought I would.”</i> <i>“This is one of the few places I know of that surrounds students in high school with nothing but talented and bright individuals while still allowing them to have fun and enjoy themselves.”</i></p>
<p>Weekend Trips and living on a college campus. <b>[Material and Relational Resources]</b></p> <p><i>“I think the trips that we took on the weekends. I think those were huge to expose me to ... Like that was the first time ever I wanted to go play. That's the first time I was able to go kayaking. Hiking. I'd never thought of going hiking before until then. Those were really good. In that they pushed me to socialize with people I wouldn't otherwise socialize with”</i></p>	<p>Bonding with peers in a non-classroom setting by <b>sharing new experiences</b>. Getting to know others, making friends. Learning to interact with people from diverse backgrounds</p> <p><i>“The biggest takeaways for me every summer were in how I was interacting with people”; “People would oh my God. In the lobby people would gather around that TV, and die to watch a jeopardy games.”</i></p>	<p>Interacting with peers Broadening interests Getting exposure to the outside world</p> <p><i>“Books too, like the types of books that people were reading. I was like oh, that sounds interesting. I'll read that”; “because of camp I created like a vocab list, and I wanted to expand my vocabulary”</i></p>
<p><b>MLI – conceptions of math, learning, and self-perceptions as a learner (AA<sub>A</sub>/AA<sub>C</sub>) being developed:</b> <i>Mathematics is a complex and interesting discipline, which I now appreciate and enjoy. I can be successful in this field by learning for understanding at my own pace, having a supportive and collaborative community around me, being accepted for who I am and accepting diversity in others, persisting, working hard, and creating collaborative relationships. Anyone can be successful at math by working hard and everyone has something unique to contribute when learning math irrespective of their racial/ethnic/socio-economic background.</i></p>		

Figure 31, Continued. Mira's MLI during/post RSMC

## Racial, class, national origin and/or gender ‘storylines’ disrupted at RSMC

The following remarks about gender, class or ethnicity during our interview portion of post-MLI and past documents lead me to conclude that Mira was trying to say that RSMC created a sense of community where diversity was valued, people were accepted for who they were, and a belief that everyone irrespective of their background has something unique to offer and can learn math through hard work was upheld. Unlike her earlier perception where she thought being Hispanic from a low-income family was a constraint to being successful and had something to do with one’s *ability* to learn and succeed, having been surrounded by the RSMC community, and seeing herself succeed through hard work in a diverse environment, Mira no longer subscribed to that view.

Narratives of gender/ethnicity/class/national origin
<p><i>“The people attend this camp come from a variety of backgrounds, having different socio-economic situations as well as ethnic backgrounds and beliefs, yet anybody, having only the desire to try, has the ability to fit in and be accepted for who they are”</i></p> <p><i>“I was suddenly in a place where Latinos were not the majority and everyone was smart and had about a million talents. And although it was intimidating at first, in the end it allowed me to grow as a person”</i></p> <p><i>“That you can offer something regardless of the background that you have, and then that influences who you become”</i></p> <p><i>“being able to succeed still there regardless of my background”</i></p> <p><i>“It wasn't like I thought I had some innate ability that other students, that my peers didn't have... I just thought I just work[ed] harder”</i></p> <p><i>“Like if you have the right resources, and the right support you're going to be fine”</i></p> <p><i>“the fact that I feel so positively about it[camp], and I am female, and I am Latino. I think it speaks to the impact that the camp can have. Specifically, because it's not just ... What do you call it. It wasn't just lip service. It was I want to figure out what it means to serve a different population, than the one that traditionally succeeds in math.. ... I mean go [Mark]! When I get rich I will give him a lot of money.”</i></p>
<p><b>MLI (A<sub>A</sub>/A<sub>C</sub>) being developed:</b> <i>A person’s race/ethnicity/gender/class has nothing to do with their ability to learn. Anyone irrespective of their background can be successful through hard work and by being part of a community that supports and values diversity.</i></p>

Figure 32. Mira’s MLI (narratives of gender/ethnicity/class) post RSMC

### **The shift in Mira's MLI**

Mira went from having a very narrow view of mathematics (*bunch of equations; problems always having one fixed way to solve*) and what it means to be successful in it (*solving lots of problems quickly; memorizing formulas; getting good grades on tests*) to a much broader and realistic view of what constitutes the realm of mathematics (*math is complex but an interesting discipline; it includes topics such as combinatorics, coding*) and what it means to be successful in it (*taking your time with the problems, working hard, creating a supportive community, thinking critically and deeply, learning for understanding*). Mira developed a set of study skills and motivation to persist in doing math when it became challenging. She learned at camp how to deal with the frustrations of failure, the fear and the discomfort that comes from working with a challenging curriculum for the first time. She began valuing learning for understanding and that it was okay for her to take her time in doing so. She also experienced the joy of problem solving that does not require external motivational factors like grades. Mira went from acting out when not knowing how to deal with frustrations of her first year experience to working hard and seeking help from others. Once she saw how the entire RSMC community (teachers, counselor, peers) came to support her learning, she felt valued and realized the importance of having a supportive community. Experiencing internal understanding, sharing it with peers and teachers, and mentoring the new campers to develop their own problem-solving skills were reward enough to keep her going.

The narrative on gender/ethnicity/class suggests that her finding RSMC to be a type of community that values diversity, was crucial to Mira's identity development. Camp became a place for Mira where she was accepted for who she was, she found

herself surrounded by people from different ethnic and social backgrounds working together and respecting each other's unique skills and perspectives. The ideational resource that Mira found so valuable was the community belief that anyone irrespective of his or her background can be successful through hard work. Finding herself succeeding and seeing others like her succeed in such a diverse environment gave her proof of the concept. This experience led Mira to the understanding that a person's race/ gender/class has nothing to do with their *ability* to learn math and in order to be successful, one needs the right resources and a supportive community that values diversity. Furthermore, Mira realizes the importance of making communities like RSMC more diverse and having minorities in leadership roles such as camp counselors can send a powerful and transformative message. In the interview, Mira recalled that the camp director was perhaps making an effort to represent minorities in the counselors' group, "I thought he [Mark] was being really strategic in the counselors that he was picking. Like my two years as a head counselor it was myself and a guy called [Jamal Nelson]. We both had similar backgrounds. He's Black, and I'm Latino... I think it's huge." Furthermore, she also recalled that her "last year as the head counselor" for the first time she saw that "there was a significant contingency of kids who were Black and Latino." This is a powerful finding and has implications for creating and maintaining a diverse student body in RSMC or any other informal learning space. It also has implications that diverse and successful alumni can serve as role models to new campers.

### **Higher Education Trajectory upon leaving RSMC**

Did RSMC have any impact on the higher educational/career paths that Mira took? If so, what? To answer this question, I explored the construct of social capital in

terms of the resources available to and accessed by the participant through social networks (e.g. parents, relatives, friends, acquaintances, peers, teachers, mentors, and organizations) before and after being a member of RSMC towards her status attainment (education/career) goals. This section describes the higher education/career trajectory that Mira envisioned for herself prior to RSMC experience and the shift that took place in this trajectory during RSMC. However, as noted earlier, Mira is now an English teacher. This begs the question - If Mira used to like math as evidenced from the previous sections, then why did she choose to become an English teacher? To answer this question, I inquired about Mira's college experience upon leaving RSMC. I will discuss findings related to her experience in college and the impact this had on her career/higher ed. trajectory. All the quotes that appear in this section are from the journals, camp evaluations, essay, survey, and the interview.

### **Figuring out what she wanted to do**

In order to determine the impact of RSMC on Mira's SC and consequently on her higher education/career trajectory, I asked her to recall her career aspirations before coming to RSMC and describe if RSMC had any influence in realizing or changing those aspirations. The following figure show examples of utterances from her recent survey, interview, and past documents that lead me to conclude that before coming to RSMC, Mira didn't know what she wanted to do. Her parents wanted her to go to a community college. She mentioned in her interview "To them [parents] education was just like they didn't care. They were just like if you get an education you're going to be better off than we are." Through her own experiences as a camper at RSMC, Mira saw the crucial role that teachers can play in any student's life and especially in a student's life from a

disadvantaged background. She recalled how her teacher, Mark, did not give up on her when she was struggling during the first year of camp. Furthermore, she also recalls how supportive and encouraging other teachers were at camp. She had a great counselor during her second year at camp who impacted her learning. This is when she first started thinking about pursuing a career in teaching math at an underprivileged high school. She wanted to help kids from disadvantaged backgrounds succeed and break through the barriers of race/ethnicity/gender/class. Mira credits RSMC for helping her figure out what she wanted to do in life. She wanted to be just like the camp teachers and counselors who have high expectations from their students, push their learning, and provide a nurturing and supportive environment. She recalled her experience as a counselor at camp (where she helped new campers with math and motivated several students from underrepresented backgrounds to persevere) as also having significant impact on her wanting to pursue a career in teaching math. We have already seen in the case of Anahi, the crucial role that Mira played in Anahi's math learning and understanding of herself as a learner of math irrespective of her background. This is exactly the kind of impact Mira hoped to make in the lives of numerous math students from disadvantaged backgrounds. Owing to her hard work, determination, and with the help of her high school teacher, Mira was accepted at one of the leading universities in the nation as a math major to fulfill her dream.

Participant's higher education/career trajectory between pre and during RSMC	Participant utterances	
Parents aspired for Mira to an education at a local college	<i>"To them [parents] education was just like they didn't care. They were just like if you get an education you're going to be better off than we are"</i>	<i>"Why don't you go to the local community college"</i>
Parents were not supportive of Mira's decision to go to a big university like University C	<i>"when I got in to [University C]... They got really upset that I would consider leaving [your home town], because they were like you're a girl you're suppose to stay at home"</i>	<i>"Why don't you go to the local community college"</i>
RSMC provided me with an experience that help me get into college	<i>"... I got into college because of math camp... My entire essays were about my experience at camp"</i>	<i>"The counselor in my second year was amazing. She was a Harvard kid. I remember it was the first time I heard of all these schools. You know he liked to ... [Mark] picked the counselors from like Carlton, and UT...The only school I heard of was UT"</i>
RSMC provided me with role-models in academia and helped me realize that I wanted to teach math	<p><i>"It was then that I realized that I wanted to be able to give other people this experience"</i></p> <p><i>"My interactions with counselors who were supportive in pushing my learning taught me the importance of having educators who had high standards, but provided a supportive environment."</i></p> <p><i>"for me it was just like, it laid a foundation for things that I need to do as a teacher myself now to reach students"</i></p>	<p><i>"I credit math camp with a lot. I cannot imagine that I would be the person that I am today without camp... That I would be the teacher that I am today without camp"</i></p> <p><i>"It hurt when I hear[d] about my friends getting pregnant, or hearing people were not doing well academically. I was like if I were a teacher I could help with that"</i></p> <p><i>"Specifically <b>I want to teach math</b>, because that's the subject that most people struggle at... Minorities specifically. I was thinking minorities specifically Latino, and Black kids"</i></p> <p><i>"I said if I could have a role in making them feel like I felt that second year in math camp. Then let's do it"</i></p>

Figure 33. Mira's SC pre and post RSMC

Participant's higher education/career trajectory between pre and during RSMC	Participant utterances	
<p>RSMC gave me the opportunity to teach and mentor new campers from diverse backgrounds as a counselor. This experience solidified my decision to teach math.</p>	<p>Mark, camp director, writes in Mira's counselor journals the following comments:</p> <p><i>"[Mira] you are an incredible counselor! I just love the way you encourage everyone, and are so sensitive to what the students understand."</i></p> <p><i>"[Mira] you are doing an amazing job...No counselor I've ever had has done better at getting the most from each student, and them all develop together! You would be a fantastic teacher (or whatever else you'd [like to] do"</i></p> <p><i>"[Mira] not only are you wonderful with your own group, but you are learning to take charge and help other counselors. I'm so happy to see you growing, and everyone at camp respects you for your hard work and commitment!"</i></p>	<p><i>"Interacting with students when I became a counselor myself also solidified my decision to teach. I was able to help students who entered at various skill levels and I liked the challenge in that."</i></p> <p><i>"As a freshman I got a phone call from [Mark] asking me to go back as a counselor"</i></p> <p><i>"I was the head counselor there for 2 years"</i></p> <p><i>"When I was a counselor he [Mark] was really invested in the conversations that I was having with the students. About math, and how to push them, and how to motivate people"</i></p> <p><i>"I love working at the [Riverside] Summer Math Camp because it puts me in contact with a wide variety of talented youth who in six weeks acquire a new way of looking not only at Math, but also themselves."</i></p>

Figure 33, Continued. Mira's SC pre and post RSMC

The quotes above illustrate that RSMC had a crucial impact on Mira's higher education/career aspirations and the decisions she made regarding choosing a major and pursuing a career as a math teacher. In this way, RSMC altered the course of Mira's educational/career journey by providing her with role models in academia who she saw first-hand impacting the learning of campers like herself every day. The support and encouragement she received as a counselor and the experience she gained in mentoring new campers also helped shape her career aspirations. Mira especially wanted to make a difference in the lives of students from minority backgrounds. She wanted to help them feel valued and break the barriers of race and class when it came to learning math just as

the camp had impacted her own learning of mathematics and her own understanding of herself as a student of mathematics. We may note from the perspective of this participant how access to and use of embedded resources in RSMC shaped Mira's decisions with respect to higher education and career aspirations.

### **RSMC characteristics/practices valued by the participant**

What practices and components of RSMC does Mira value and credit, if any? In this section I identify particular practices that Mira values and mentions either in her past documents or in her recent correspondence, survey, and interview. These are some of the practices/components of RSMC that led to the impact on Mira's MLI and higher education/career trajectory as discussed earlier. The following figure shows excerpts from Mira's past data sources in which she mentions aspects of camp that she likes or appreciates.

RSMC Practices/Components Valued	Participant utterances	Data Source
Teaching practices ( <i>deep understanding, providing support and encouragement, having high expectations, persistence, supporting learning at your own pace, productive struggle</i> ) at RSMC	<p><i>"[Edmund] is a very good teacher...[Tony] was also a great teacher and, like [Edmund], I liked the fact that they came around to our rooms during study session and offered to help."</i></p> <p><i>"My teachers and my counselor have taught me...it is always better to take your time and truly understand a proof or problem and only get a few done than to rush through them and not really understand what has happened."</i></p> <p><i>"There was nothing to feel bad about if you were in a different problem set or if you had done less proofs than anybody else"</i></p> <p><i>"taught me to look at math more carefully and not to rush through things"</i></p> <p><i>"The best thing I liked...was that you were allowed to work at your own pace"</i></p>	Data Source: Camp evaluations, 1998
Camp Curriculum	<p><i>"I enjoyed the classes and found them interesting...Combinatorics I found extremely interesting."</i></p> <p><i>"I began to enjoy [Analysis] class, especially when I began working with sequences"</i></p> <p><i>"This camp has made me appreciate and enjoy math more that I ever thought I would."</i></p>	Data Source: Camp evaluation, 1998; Camp essay, 2000

*Figure 34. RSMC components valued by Mira as noted in her past data sources*

RSMC Practices/Components Valued	Participant utterances	Data Source
Study groups ( <i>bonding, feeling accepted by peers, learning through discourse and collaboration, valuing diversity, enjoying learning</i> )	<i>"This is my third year attending the [Riverside Summer Math Camp] and it never ceases to amaze me how incredible the people are here" "...my group was great. Whenever I got stuck on a problem, there was always someone to ask for help"; "The people attend this camp come from a variety of backgrounds, having different socio-economic situations as well as ethnic backgrounds and beliefs, yet anybody, having only the desire to try, has the ability to fit in and be accepted for who they are"; "This is one of the few places I know of that surrounds students in high school with nothing but talented and bright individuals while still allowing them to have fun and enjoy themselves."</i>	Data Source: Camp evaluation, 1998; Camp essay, 2000
Camp Counselors ( <i>help received from her counselors as well as being a counselor herself</i> )	<i>"[Anna] was an awesome counselor. She knew how to explain things very clearly and always gave helpful hints. I think she was the best counselor at this camp and I am very grateful that she was my counselor. I liked that she wasn't uptight...She knew to make you think deeply about the problems and always had a word of praise when you accomplished something."; "I love working at the [Riverside Summer Math Camp] because it puts me in contact with a wide variety of talented youth who in six weeks acquire a new way of looking not only at Math, but also themselves."</i>	Data Source: Camp evaluation, 1998; Camp essay, 2000
Sense of a collaborative community at RSMC ( <i>provides help and support, values diversity, environment of acceptance and mutual respect, opportunity to grow as a person</i> )	<i>"The people attend this camp come from a variety of backgrounds, having different socio-economic situations as well as ethnic backgrounds and beliefs, yet anybody, having only the desire to try, has the ability to fit in and be accepted for who they are"</i> <i>"I was suddenly in a place where Latinos were not the majority and everyone was smart and had about a million talents. And although it was intimidating at first, in the end it allowed me to grow as a person"</i> <i>"This is my third year attending the [Riverside Summer Math Camp] and it never ceases to amaze me how incredible the people are here"</i> <i>"I am able to take with me something new and valuable that I've learned here...and apply it to my normal life outside of math camp, helping me to become that much of a better person"</i>	Data Source: Camp evaluation, 1998; Camp essay, 2000

Figure 34, Continued. RSMC components valued by Mira as noted in her past data sources

When asked in the recent survey and interview about the practices/characteristics or elements of RSMC that Mira came to value, she identified the following – *sense of a collaborative community that values diversity and supports every student's learning, support and encouragement from Mark, her peers in the study groups, teaching practices (such as time to explore the problems for deep understanding, emphasizing the process over the answer, not giving the answer but letting you discover it yourself, persistence, life skills), help received from her camp counselor as well as the experience of being a counselor herself, and social aspects such as weekend trips* as most significant for her.

Regarding the sense of a collaborative and diverse community, Mira stated that RSMC creates an atmosphere where students understand, “That you can offer something regardless of the background that you have”, which has a profound effect on students especially in their formative years “and ... influences who you become.” She explained that RSMC’s practice of valuing diversity and helping a diverse body of students succeed and transform into better human beings is not just “lip service.” Her own transformative experience is a testimony to the type of community RSMC creates. She stated “the fact that I feel so positively about it [camp], and I am female, and I am Latino. I think it speaks to the impact that the camp can have. Specifically, because it's not just ... What do you call it. It wasn't just lip service. It was I [Mark] want to figure out what it means to serve a different population, than the one that traditionally succeeds in math...”

Regarding the support and encouragement that she received from her camp teacher Mark Weitzman, Mira stated “I got a lot of support. I remember [Mark] would grade some of my problems sets. He would draw little bunnies...[or] Turtles right”, and suddenly I felt good”. She appreciated that fact that when she was having a difficult time

during her first year at camp, Mark did not give up on her. He invited her high school teacher to camp to have an intervention and made sure that Mira continued at camp and came back the following year as well. She recalled with great admiration the time Mark took to check up on her progress at camp as she stated “Like just that investment in my learning. Like I was 1 of 70 kids, and he was really invested in what I was doing.” Furthermore, she also admires Mark’s efforts for trying to make RSMC a more diverse environment as she recalls “last year as the head counselor” for the first time she saw that “there was a significant contingency of kids who were Black and Latino”. She also appreciated the fact that Mark was making an effort to provide more leadership opportunities to traditionally underrepresented students “I thought he [Mark] was being really strategic in the counselors that he was picking. Like my two years as a head counselor it was myself and a guy called [Jamal Nelson]. We both had similar backgrounds. He's Black, and I'm Latino... I think it's huge.”

With respect to her peers in the study groups, Mira mentioned that “The group in the evening I think was huge for me. It taught me about how learning could be student directed...It also taught me about how there are more resources than just the teacher, and what it is to mean to take advantage of those resources.” Furthermore, Mira values the support she received for her group mates when she found herself struggling with challenging problems. She recalls that her “entire group” would become her resource and states with fondness “The best part [about the camp] were the group study at night 6 to 10.”

Mira finds the counselor mentorship and teaching practices of the camp to be important components of RSMC. She appreciated how teachers and counselors would

help the campers discover the solutions to the problems themselves instead of giving them the answers. She mentioned in her survey that “My interactions with counselors who were supportive in pushing my learning taught me the importance of having educators who had high standards, but provided a supportive environment.” Similarly, Mira valued how her counselor in her second year of camp was “phenomenal” and had a crucial impact on her learning as she recalls, “The counselor in my second year was amazing. She was a Harvard kid.” Mira credits the camp for providing her with role models in excellent teachers and counselors. This impacted her own aspiration to pursue a career in teaching as she recalls, “I credit math camp with a lot. I cannot imagine that I would be the person that I am today without camp... That I would be the teacher that I am today without camp.” Mira values the experience she had as a counselor at RSMC mentoring new campers and helping them with their learning.

Mira also appreciates the social aspects of the camp. In her interview she stated, “I think the trips that we took on the weekends. I think those were huge to expose me to ... Like that was the first time ever I wanted to go play. That's the first time I was able to go kayaking. Hiking. I'd never thought of going hiking before until then. Those were really good. In that they pushed me to socialize with people I wouldn't otherwise socialize with.” She valued this practice of bonding with peers in a non-classroom setting by sharing new experiences, which led to broadening her interests and learning how to socialize with a diverse group of students.

### **Summary of RSMC practices valued**

Some of the same practices that were valued by Mira when she was a high school student attending RSMC were also valued by her in her recent retrospective interview,

and survey. The figure below summarizes Mira's valued practices about RSMC from the past and the present. The highlighted cells indicate the common ones. These are elements of RSMC that led to the impact on Mira's MLI and higher education/career trajectory overtime.

Table 11

*Summary of RSMC practices/components valued by Mira*

RSMC Practices/components valued in the Past (while attending camp during high school)	RSMC Practices/components valued in the Present (in retrospect)
Teaching practices ( <i>deep understanding, providing support and encouragement, having high expectations from campers, persistence, supporting learning at your own pace, productive struggle</i> ) at RSMC	Teaching practices ( <i>deep understanding, providing support and encouragement, having high expectations from campers, persistence, supporting learning at your own pace, productive struggle</i> ) at RSMC
Camp counselors ( <i>help received from her counselors as well as being a counselor herself</i> )	Camp counselors ( <i>help received from her counselors as well as being a counselor herself</i> )
Study groups ( <i>bonding, feeling accepted by peers, learning through discourse and collaboration, valuing diversity, enjoying learning</i> )	Study groups ( <i>bonding, feeling accepted by peers, learning through discourse and collaboration, valuing diversity, enjoying learning</i> )
Camp curriculum ( <i>challenging and interesting, combinatorics, analysis</i> )	Mentorship from the camp director at RSMC ( <i>invested in your learning, provides help, support, encouragement, values diversity</i> )
Sense of a collaborative community at RSMC ( <i>provides help and support, values diversity, environment of acceptance and mutual respect, opportunity to grow as a person</i> )	Social aspects at RSMC ( <i>weekend trips – trying new things, exposure to the outside world, socializing and bonding with a diverse group of peers, broadening interests</i> )
	Sense of a collaborative community at RSMC ( <i>provides help and support, values diversity, environment of acceptance and mutual respect, opportunity to grow as a person</i> )

### Case Summary with respect to the research questions

According to Mira RSMC not only played a significant role in changing her perceptions about learning math and herself as a learner of math i.e. MLI development

but the camp was instrumental in her finding acceptance and breaking through the barriers of race, ethnicity, gender, or class during the formative years of her life. Mira went from having a very narrow, rote, and non-creative view of mathematics and what counts as success to a much broader and realistic view of what constitutes the realm of mathematics and what it means to be successful in it. Mira developed a set of study skills and motivation to persist in doing math when it became challenging. She learned at camp how to collaborate with others and have fun with her friends in the process of learning. Experiencing internal understanding, sharing it with peers and teachers, and mentoring the new campers to develop their own problem-solving skills were very rewarding for her. Furthermore, camp became a place where Mira was accepted for who she was, she found herself surrounded by people from different ethnic and social backgrounds working together and respecting each other's unique skills and perspectives. The ideational resource that Mira found so valuable was the community belief that anyone irrespective of his or her background can be successful through hard work. Finding herself succeeding and seeing others like her succeed in such a diverse environment gave her proof of this concept. This suggests that she came to the conclusion that the properties of race, ethnicity, gender, or class have nothing to do with one's abilities to understand and learn math. She came to believe that in order to be successful, one needs hard work, the right resources, and a supportive community that values diversity.

Before coming to RSMC, Mira didn't know what she wanted to pursue as a career. Her parents wanted her to go to a community college. However, RSMC had a crucial impact on Mira's higher education/career aspirations and the decisions she made regarding choosing a major to pursue a career as a math teacher. Through her own

experiences as a camper at RSMC, Mira saw the crucial role that teachers can play in any student's life and especially in a student's life from a disadvantaged background. This is when she first started thinking about pursuing a career in teaching math at an underprivileged high school. She wanted to help kids from disadvantaged backgrounds succeed and break through the barriers of race, ethnicity, gender, class just as she had at camp. Mira credits RSMC for helping her figure out what she wanted to do in life. She wanted to be just like the camp teachers and counselors who have high expectations from their students, push their learning, and provide a nurturing and supportive environment. She recalled her experience as a counselor at camp (where she helped new campers with math and motivated several students from under represented backgrounds to persevere) as also having significant impact on her wanting to pursue a career in teaching math. Owing to her hard work, determination, and with the help of her high school teacher, Mira was accepted at one of the leading universities in the nation as a math major to fulfill her dream of becoming a teacher.

The particular practices and components that Mira came to value over time as mentioned either in her past data (essay, evaluations) or in her recent, survey and interview include

- Sense of a collaborative community that values diversity, provides help and support when needed, upholds and practices the belief that everyone is capable of learning and contributing irrespective of their background.
- Teaching practices such as emphasis on deep understanding and persistence, emphasis on learning at your own pace, valuing the process more than the answer, support and encouragement provided by teachers, and having high expectations.

- Study groups that afford student directed learning, encourage bonding, learning through discourse and collaboration among peers, enjoying the process of learning with friends.
- Camp curriculum that is challenging, interesting and includes topics such as Analysis, Combinatorics to which students aren't normally exposed to in most high schools.
- Mentorship from the camp director at RSMC. A practice that provides help, support, encouragement, and guidance to new campers who may initially find it difficult to connect with peers or counselors in a diverse setting.
- Counselors who serve as an aid to help campers with their camp course work and an opportunity for returning campers to become counselors themselves in order to mentor a new cohort of campers.
- Social aspects such as weekend trips that provide opportunities to bond with peers, try new things, and get an exposure to the outside world.

### **Additional Findings: So, what happened in college?**

Mira was set on her path to become a math teacher by pursuing her undergraduate degree in Mathematics at one of the top-ranked schools in the US. So, what happened in college that made her switch majors and leave the field of mathematics altogether? The script below from my interview with Mira illustrates the challenges and discriminatory situations Mira faced during her two semesters of Calculus at college.

Mira: I went in ... I went to [University C]. I went in because of camp with the intention to be a math major. With the intention of becoming a math teacher. After two quarters of calculus at [University C] I quit math. I had a really, really, really negative experience there. That contradicted everything that I had learned before. It was the first time that both gender, and race came into my mind. As something that was weeding me out of doing something that I thought I could be good at.

Mira: Yeah, so I started the calculus series. I had this professor, professor [...]. He was terrible. I remember I would spend more time ...

Mira: I remember spending more time in office hours than at class in section combined. We had 5 hours of class, and section. Right?

Mira: I was in office hours every day for multiple. Like any TA that had office hours I was there. I was acing all of the homeworks.

Mira: Never failed like all hundreds on homework.

Mira: I would take the mid-terms and I would be like in the 5th percentile. I mean I was just destroyed.

Mira: I didn't know what was happening, so I went to ... I remember I was like I need to talk to the professor. There's a disconnect here. I cannot identify it.

Mira: The TA's are not helping me identify it. I did have one wonderful TA who I think felt pity for me.

Mira: I was determined to talk to the professor, and figure it out. I made an office hours appointment with the professor, and I explained to him how well I was doing on his homeworks.

Mira: -And how I was just bombing his exams.

Mira: His response was, "well [Mira] not everyone can be an engineer. "I was so livid. I was like first of all I don't want to be an engineer.

Mira: Secondly I want to be a teacher so I could help people.

Mira: I was like it is your job to teach me, and it's your job to figure out what are my misconception.

Mira: What are the obstacles. What's going on.

Mira: How I may overcome them, and he didn't do any of that. The course was meant to weed people out, and they succeeded. They weeded me out.

Mira: After that interaction, he was going to be my professor for the entire year for that calculus series.

Mira: I was just like no, I'm done. I cant.

From the script above we may note that Mira had a negative experience with her calculus professor and felt discriminated against. Mira felt confused about the disconnect she was experiencing in her homework and exams. While she was acing her homework,

she couldn't understand why she was doing so poorly on her exams. A hardworking and determined student, Mira tried to reach out to her professor for help. However, instead of providing support and helping Mira understand what she needed to do to perform well in his class, the professor completely shut her out in a way that fractured her math learning identity. By telling her that "not everyone can be an engineer", the professor was sending her a message to quit. This experience went completely against what she was taught and had experienced in camp (where everyone could succeed with hard work irrespective of their background). Mira's pride and dignity were hurt by this negative experience and she had no one to turn to for help. Since this was the only professor who was assigned to teach the entire calculus series and not wanting to prolong this hurtful experience, Mira decided to quit math. In this way Mira was marginalized or rather in her own words she felt that she was "weeded out." The professor at University C had managed to wound Mira's learning identity but he could not destroy her. She did not give up on her education or drop out of college. She decided to switch her field of study to her secondary interest and continued on with her original goal of becoming an educator. She may not be teaching math but she could still help high school kids who struggle in English. She decided on being a role model to English language learners by becoming an English teacher who was a Latina. Mira graduated with a B.A. in Comparative Literature and Political Science and a Masters in Education from University C. She is a successful high school teacher of English Literature.

#### **Case 4: Samara**

I first met Samara over Skype for our first interview. Samara is an African-American woman in her late twenties, with a confident and humorous personality. Samara grew up in a poor neighborhood in a small town. She was raised by a single mother who had some high school education and worked as a postal mail delivery person. Samara has three other siblings and she is a first generation college student in her family. Samara mentioned in her interview that her “family was pretty low social economic status” and it was a community effort to get her to come to math camp. She recalled, “Um, actually, I asked my church to donate things like lotion and shower gel, just stuff for camp. My family can't afford a couple hundred dollars to do that. So, it was a community effort to get me there.” Samara started out as a computer science and mathematics major at University C (the same university that Mira attended) but later switched to a non-stem field. She graduated with a B.A. in African and African American Studies from University C. She wanted to become an engineer or a computer scientist after discovering her love for computers and math at RSMC. She recalled her experience as a camper being surrounded by so many successful people as having a significant impact on her wanting to pursue a career in STEM. Samara credits her camp teacher Mark for giving her the confidence to set her sights high and helping her to get into one of the top-ranked schools to pursue higher education. Owing to her hard work, determination, and with the help of her teacher Mark, Samara was accepted into one of the leading universities in the nation as a computer science and math major to fulfill her dream. Unfortunately, she felt that she was marginalized from the field in college and ended up switching to a non-stem major. However, Samara did not give up on her

passion. She was finally able to return to her original interest in computers and is now pursuing a graduate degree in theology and tech literacy at a seminary affiliated with an Ivy League university. She plans to become a computer chaplain, where she will empower people in the Christian space by teaching them about problem solving and digital citizenry. Through her experiences in college she became increasingly aware of the divide or gap that “exists between the technological haves and have nots and that goes to STEM, as well” especially for “a lot of women, a lot of people of color.” Samara would like to work towards addressing this gap and “empower people in [the] digital space” by sharing her experiences, her knowledge and skills in the technology arena through her church. Samara credits her RSMC experience as playing a crucial role in helping her making this return to STEM.

### **Trajectories of identities: MLI co-construction and shifts**

In this section I will describe the story of Samara, a young Black graduate student of theology and tech literacy, and her experiences at an informal math summer program - RSMC during her high school and undergraduate years. In order to determine the identity trajectory that RSMC helped create for Samara, I will first explore the path she was already on prior to coming to RSMC. This will entail describing her perceptions about learning math and herself as a learner of math in her high-school classroom. Next I will describe the shift in the MLI trajectory that RSMC helped create for Samara.

### **Pre-MLI: What constitutes learning in Math?**

In order to determine the impact of RSMC on Samara’s MLI, I asked her to recall her beliefs about learning and doing math prior to coming to camp as well as describe her

perceptions of herself as a student of mathematics. We shall call this Samara's Pre-MLI.

The retrospective interviews are the primary data sources for determining her Pre-MLI.

The following figure shows an example of utterances from her interviews that lead me to conclude that for Samara prior to RSMC learning math meant memorizing rules and formulas that the teacher gave and being able to regurgitate it during exams, while doing math meant being able to quickly solve problems that always had one exact answer like a calculator. She saw math itself as a series of formulas and thought that the only topics that constituted math were algebra and arithmetic.

<b><i>Perceptions about learning/doing math before RSMC</i></b>	<b><i>Participants' utterances</i></b>		
Problems have one right answer, should be found quickly using rudimentary methods such as applying formulas.	<i>"learning and applying the formula"</i>	<i>"Doing" mathematics was also very rudimentary"</i>	<i>"... it meant performing functions much like a human calculator."</i>
Memorizing rules and formulas without any conceptual understanding	<i>"Learning meant remembering facts"</i>	<i>"... it meant performing functions much like a human calculator."</i>	
Math is a series of formulas needed for various reasons.	<i>"for the most part, I saw mathematics as, uh, a series of formulas [needed] for various reasons"</i>	<i>"pre-algebra, arithmetic"</i>	<i>"I had sort of been exposed to some of the topics, uh, that you might get in your average public school education"</i>
Teacher tells what to do to pass a test	<i>"[teachers] embed you with these mathematical skills so that ... you could pass a test"</i>		
<b>Emerging theme</b>	Memorizing rules and formulas (given by the teacher) to find the right answer quickly like a calculator and to pass the test. Math itself is just algebra or arithmetic and needs a series of formulas.		

*Figure 35. Samara's perceptions about learning/doing math before RSMC*

**Pre-MLI: Am I good at math? (Self-perceptions about being a learner of mathematics)**

When I asked Samara to describe her self-perceptions as a student of mathematics prior to RSMC, she said she considered herself “really good at math.” This perception was based on her understanding of what math was, her being put in gifted and talented classes at her school, her grades, and the discourses about being “good” at math that were prevalent at her school. These discourses equated competence with memorization of formulas, speed, and high scores on tests. Samara was able to adhere to the practices of her learning environment at school and she recalled she “got really good grades” and was put in the “gifted and talented classes”. Samara although attended an underprivileged school in a “poor neighborhood”, it was predominantly White. She also mentioned that although she considered herself good at math in school, her family thought of it as “acting White”. She recalled in the interview “they [family] thought that I was, you know, acting white when I used a big word. So, it was still, um, intelligence or smartness was coded as being white. Um, and it wasn't an identity, that I could hold as a black -- a young black woman.” This led to Samara to believing that since she is good at math and clearly not white, then she must be an exception among her community. Samara developed a math learning identity to succeed in the practices that were valued by her high school learning environment and negotiated the meaning of being black and also being good at academics – *I am good at math because I can memorize all the formulas and rules, get good grades, and am placed in gifted and talented classes. However, I must be an exception among the black population.*

**Pre-MLI: Subscribing to racial, class, and/or gender ‘storylines’ in  
the context of learning math**

The following remarks about race, gender, or class during our interview portion of pre-MLI and from her past camp essay lead me to conclude that Samara was trying to say that she is good at math despite all the race, gender, and class constraints of her situation. Therefore, she must be an exception to what is considered the norm within her community.

Narratives of gender/race/class
<p>“I’m the oldest of four kids, single mom... we didn’t have a lot of money”</p> <p>“so many of the people that were in my family or people that I knew that were adults were just trying to make it. And they had a lot of blue-collar jobs or lower positions that they would just hold for years and years. Custodial positions, home caregivers, these kinds of things.”</p> <p>“I attended over crowded public school in poor neighborhood in [...] I went to a predominately white school... I feel like the I was one of like two or three kids of color”</p> <p>“I don’t recall ever having a teacher who was black except for a substitute teacher who was a black man. Um, I’ve had female teachers, I did not have any female teachers of color.”</p> <p>“I was asked to go into this special little class for people who had, um, anger issues and I had never done anything angry. I’m looking back now and I feel like that might have been, um, because I was black. I don’t know any other reason besides them preemptively ... I don’t know... I had a good experience, otherwise, um I was put in gifted and talented classes”</p> <p>“I feel like in junior high, uh, it was when I started taking pre-algebra, um, and in high school is when I took like the extra physics class or the extra science class. Um, ...there weren’t a lot of students of color”</p> <p>“I didn’t spend a lot of time with other people of color, except for my family, but they all thought it was very odd, they thought I talked white.”</p> <p>“they [family] thought that I was, you know, acting white when I used a big word. So, it was still, um, intelligence or smartness was coded as being white. Um, and it wasn’t an identity, that I could hold as a black -- a young black woman”</p>
<p><b>Emerging Theme [MLI (A<sub>AA</sub>/ A<sub>AC</sub>) being developed]:</b> <i>I am good at math despite being a Black female from a low-income family who attended schools for the underprivileged. It is not the norm for someone like me to be good at math, so I must be an exception.</i></p>

*Figure 36. Samara’s MLI (narratives of gender/race/class) before RSMC*

### Post-MLI: After the culture shock: moving onwards and upwards

The findings in this section illustrate how RSMC helped create an inbound STEM identity trajectory for Samara by affording her material, relational, and ideational identity resources (Nasir & Cooks, 2009) throughout her stay. I will show how over the course of her affiliation with RSMC, Samara became more connected to the practice of mathematics and developed a broader and holistic learning identity in the context of math in particular and STEM in general. Samara's retrospective accounts in two interviews and her handwritten camp evaluations from when she was a camper and counselor at RSMC are used as data sources to help tell her story.

### First year at RSMC - challenges and struggles

The comments below from my first interview with Samara illustrate the challenges she faced during her first year at camp.

Table 12

#### *Samara's first year challenges at RSMC*

Participant utterances	Data source
<i>"And then I go to Math Camp and they are speaking Mandarin... It's not the same. Um, and I was on the struggle bus. Okay?"</i>	Interview1
<i>"You're suddenly on shifting fan, you're no longer the smartest person in the room. You're no longer one of the people that just [snaps fingers] gets it like that."</i>	
<i>"there was a lot that just sort of went over your head"</i>	
<i>"it was like putting a fire hydrant to your face ... trying to drink... Uh, (laughing) and not choke"</i>	
<i>"So, there was so much. Every day, learning new concepts, and it just got harder and harder"</i>	

From the table above we may note that during the first year at camp Samara felt lost, confused, overwhelmed, and intimidated. The material in her camp courses was quite challenging and new to her. In the previous section we noted that Samara seemed to have a positive attitude about her proficiency in math. But what counted as success and being good at math in her high school is revealed in her conception of learning/doing math - *memorizing formulas, algebra and arithmetic, getting the right answer like a calculator, and making good grades*. This very view of what constituted math and learning was being shaken by the practices of her new learning environment at RSMC. Furthermore, she found herself in company of peers who were better prepared and more knowledgeable than her, as she recalls, “you’re no longer the smartest person in the room. You’re no longer one of the people that just [snaps fingers] gets it like that.” This was also a new experience for her. It was difficult for Samara to stop seeing math as just a series of formulas and equations that needed to be solved quickly. She had to figure out a way to collaborate with her peers and take her time to understand the problems. Samara survived her first year at camp with the help of her counselor. She was able to bond with her counselor. Samara came to look up to her counselor as a role model. She received from her counselor the emotional support she needed to acclimate to her new learning environment. She recalled her counselor with fondness in the interview, “my first counselor, [Salma]! I loved that she was a math person, but she also had all these other fast-starts. So, she completely broke the mold of what it meant to be a counselor to me... she exposed me to Simply Orange, orange juice. She brought it to the session one evening, and I still drink it to this day and um, like, little things like that make such a huge difference... I remember seeing her at [University C] and being like, You! You are

part of the reason I am here.” Samara also recalls having a successful time in her Mathematica class during her first year, which went a long way in boosting her confidence at camp. She recalled her experience in the Mathematica class with much fondness, “in Mathematica class, which is actually where I excelled... I drew a picture of Betty Boop. Eyes, eyelashes, lip ... like, it was twenty-six equations just for her eyelashes and I loved it. Oh, my gosh! then, in mathematica, I coded those equations into the program with, um, movement, along the X and Y axes, so that her eyes would open and close or her mouth would open and close,... using mathematica, and that's what I did during mathematica class. And I loved it!”

The above illustrates that that the relationship that Salma, the counselor built with Samara seemed to serve the purpose of providing Samara with a sense of belonging in mathematics and at her new learning environment. Furthermore, Salma also became a role model for Samara and partly the reason why Samara ended up pursuing her higher education at University C. In this way, Salma served as a relational identity resource for Samara. We may also note that the RSMC course Mathematica served as an important material resource in the form of challenging, non-standard curriculum. Because Samara was able to persist through successfully in her Mathematica course, she experienced a sense of achievement and joy. This illustrates that the challenges in the material resources and the support structures in the relational resources to persist through the challenges were essential in creating opportunities through which Samar was on a path to shift her MLI trajectory. The above is just one example of how RSMC offers identity resources to its students. In the following section I will discuss various practices of RSMC through

which the core identity resources were made available to and taken up by Samara during her time at RSMC.

### **Experiencing RSMC – taking up the identity resources**

In the table below I will argue that the three core identity resources as described in Nasir and Cooks (2009) were made available by RSMC (through its various components) and taken up by the participant. Note, that the availability of and the value of these resources comes from the participant herself. I will then show how the participant's pre-MLI was interrupted and shifted on a different trajectory with a new and more profound understanding of herself as a learner and of mathematics as a discipline. The data sources from which Samara's quotes are used in the figure include - past data (camp evaluations, 2003, 2004) and present data (interviews).

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>Camp fosters <b>deep understanding, persistence, and a broad understanding of mathematics</b> by offering a <b>interesting/challenging curriculum, ample time to explore and struggle</b> with problems.  <b>[Material Resource; Ideational Resource]</b>  <i>“it [math] meant exploring a problem and figuring out something for myself.”</i>  <i>“I felt like mathematics had more words to it, not just letters like algebra. There was a language to math and an entire way of communicating through logic, permutations, or programs like Mathematica.”</i>  <i>“It [camp] certainly completely blew the lid off of my, uh, understanding of what math was... Basically, we were being exposed to math theory”</i></p>	<p>Learning for understanding, Persistence, productive struggle.  <i>“I like the attitude of the class [number theory]: here is a problem let’s explore it”</i>  <i>“It provided extra time to work on the problems”</i>  <i>“everybody was encouraged to research things, for opinion”</i>  <i>“it was completely far field from anything I had ever done before...So, I feel like, um, that was such a huge takeaway, just to see so much more of the field that I might - might not otherwise have been able to do without having to have signed up for a whole bunch of college classes”</i></p>	<p>Appreciating and understanding what constitutes math    Deep understanding    Learning a new concept    <i>“I got to understand more and even learn the new topics” pg. 1</i>  <i>“I started liking Mathematica as I liked learning an introduction to Visual Basic”</i>  <i>“that’s what I did during mathematica class. And I loved it!”</i></p>
<p>Camp invites former campers to be counselors to the new cohort of campers  <b>[Relational Resource: Interaction with counselors]</b>  <i>“the thing that stood out to me in first summer was that my counselor who was uh, [Salma Garcia], I think, she was a student at [University C] and she was also [from a small town predominantly Hispanic]”</i>  <i>“She [counselor] would have us go through a problem despite gripes and complains. She brought us food twice a week and joked around with us. I felt comfortable talking to [Betty] because she was an honest and light hearted person”</i>  <i>“I understand everything [Cory] talks about...He comes during our study group and helps”</i>  <i>“I feel like one of the [counselors] teachers, [Cory Parson]? ... obviously I remember his name and I don’t know anybody’s name, but I remember his name... so I recall specific individuals, um, who did make an effort. He was one of them who did make an effort to be friends with the campers...”</i></p>	<p>Seeing counselor as a role model, mentor, and taking up the offered support to improve learning    <i>“my first counselor, [Salma]! I loved that she was a math person, but she also had all these other fast-starts. So, she completely broke the mold of what it meant to be a counselor to me... she exposed me to Simply Orange, orange juice. She brought it to the session one evening, and I still drink it to this day and um, like, little things like that make such a huge difference... I remember seeing her at [University C] and being like, “You! You are part of the reason I am here”</i></p>	<p>Building positive relationships  Understanding how to learn math in different ways and persisting through problems  Finding a mentor and support structure  Finding role-models    <i>“a camp counselor embodies a lot what your experience is going to be like. So, their personality, their attitude, the way that they, um, approach their position can really make a difference to whether or not you feel like you fell through the cracks, whether or not you, um, feel like your experience was enjoyable in some ways”</i></p>

Figure 37. Samara’s MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>Camp fosters aspects of <b>growth mindset</b> and a learning environment that makes you a stronger person– by teaching how to <b>deal with failure</b>, distilling <b>confidence</b> by having you go through something challenging, developing <b>persistence</b>, and appreciating <b>diverse perspectives</b>.</p> <p><b>[Ideational Resource]</b>  <i>“expose you to these concepts to push you, to force you outside of your mathematical comfort zone, your intellectual comfort zone, your social comfort zone”</i>  <i>“I think, the ideology behind or the methodology, pedagogy of Math Camp is there for that very reason, um, to where students who might not otherwise thought themselves able to handle a college environment or, um, maybe not have thought, “Maybe I can do, uh, you know, a degree in mathematics,” or be a math professor, or whatever the case”</i></p>	<p>Learning to deal with failures as an opportunity to grow and overcome  Working hard and persisting in solving problems  Learning to appreciate diversity of skills in herself and other people.</p> <p><i>“to give you a series of experiences of failures, so that you could have them out of the way”; “Um, to give you an opportunity to do something you didn't think you could do”</i>  <i>“I recall trying to think of something that I could solve, like I am trying -- I literally was trying to figure out a mathematical PhD dissertation kind of topic of what I, as a fifteen-year old, on my own, could figure”</i></p>	<p>Adopting a view that anyone can be successful and is capable</p> <p>Learning that hard-work, persistence, and collaboration lead to success</p> <p><i>“Camp teaches me to work with different kinds of people. Being surrounded by so many intelligent people, I get to meet all kinds of opinions and perspectives. I feel I am able to do more as a person and I am able to stretch my capabilities”</i></p> <p><i>“My assurance level constantly increases”</i></p>
<p>Study Groups  <b>[Material, Ideational and Relational Resources]</b></p> <p><i>“So, you had your peers. You felt more comfortable going to them”</i>  <i>“in the evenings, we'd go do our homework sessions and they were intense, four hours at a time, uh, so much candy”</i>  <i>“some of us would either go/sneak off to the arcade and play video or whatever.”</i></p> <p><i>“I actually didn't. Uh, I didn't until after Math Camp. I knew that I was smart and I like - I liked books and stuff, but it wasn't until after Math Camp that I started gushing about math the same way people gush about band camp... I guess it's -- like, not that it wasn't okay before, but I am realizing, I can now access this whole other side of me. Like, I love sci-fi, I love all of these other things, computers ...”</i></p>	<p><b>Peers</b> can be a resource for learning  <b>Bonding</b> with group mates through the process of doing some very challenging math together.  Learning to get along with a diverse group of peers, <b>learning through discourse</b> and appreciating <b>diverse perspectives</b> when learning  <i>“[Tommy] and I would often work on a problem separately then ask each other for help at certain points”; “[Betty] would sometimes have us go up to the board to finish a problem”</i>  <i>“The opportunity to explore ideas and opinions for myself and from others helped me to get comfortable thinking about different types of concepts.”</i></p>	<p>Forging positive and collaborative relationships with peers and learning.</p> <p><b>Enjoying math and other STEM interests.</b></p> <p><i>“Camp teaches me to work with different kinds of people. Being surrounded by so many intelligent people, I get to meet all kinds of opinions and perspectives. I feel I am able to do more as a person and I am able to stretch my capabilities”</i>  <i>“Every year I am able to connect with all kinds of people”</i></p>

Figure 37, Continued. Samara’s MLI during/post RSMC

Characteristics/Practices of the Learning environment	Behavior developed	Measuring success
<p>Teachers at RSMC are invested in your learning and future, provide support, build your confidence, and offer encouragement. <b>[Ideational and Relational Resource]</b></p> <p><i>"[Edmund] was available and ready to answer questions"</i></p> <p><i>"They [teachers] also talked to me about my college choice and encouraged more from me"</i></p> <p><i>"everybody was encouraged to research things, for opinion"</i></p> <p><i>"I like the attitude of the class [number theory]: here is a problem let's explore it"</i></p> <p><i>"[Dan] and his wife ... offer help in a way that does not spoil a problem for you"</i></p>	<p>Developed confidence</p> <p>Learning for deep understanding, Persisting through challenging problems.</p> <p><i>"I think, the ideology behind or the methodology, pedagogy of Math Camp is there for that very reason, um, to where students who might not otherwise thought themselves able to handle a college environment or, um, maybe not have thought, "Maybe I can do, uh, you know, a degree in mathematics," or be a math professor, or whatever the case"</i></p>	<p>Believing in her own capabilities</p> <p>Learning is a reward in itself.</p> <p><i>"So, that conversation [with Mark], um, really jostled my entire understanding of my capabilities and my capacity "</i></p>
<p>Social activities such as weekend Trips, picnics, etc.</p> <p><b>[Material and Relational Resources]</b></p> <p><i>"The picnics every Friday were also a time of rest and respite since the entire week we're doing 4 hour problem sessions or problem, time where we'd be working on the problem set which were very intense and intensive. So, to have them on Fridays, sort of was something to look forward to and was also much needed"</i></p>	<p>Bonding with peers in a non-classroom setting by <b>sharing new experiences.</b></p> <p>Unwinding before another week of intense math</p> <p>Getting to know others, making friends.</p> <p><i>"weekend and rec activities provide me with things, I could never do at home"</i></p> <p><i>"Last summer was the first time I had ever canoed. If not for math camp, I would never have done it"</i></p>	<p>Interacting with peers</p> <p>Broadening interests</p> <p>Getting exposure to the outside world</p> <p><i>"the service project...picking up rocks to build a dam was practical...the overall experience was enthusing and inspiring"; "the opportunity to hang out with friends and have friendly [bowling] completion...was refreshing"</i></p>
<p><b>MLI - conceptions of math, learning, and self-perceptions as a learner (<math>A_A/A_C</math>) being developed:</b> <i>Mathematics is a vast discipline that has a language to communicate different ideas through diverse topics such as logic, permutations, Mathematica. I can be successful in this field or any other field by believing in my capabilities, persisting, working hard, creating collaborative relationships, learning for understanding, and having a support structure.</i></p>		

Figure 37, Continued. Samara's MLI during/post RSMC

### **An identity independent of learning**

The following remarks about race/gender/class during our interview portion of post-MLI and past documents lead me to conclude that Samara was trying to say that she was able to connect with a diverse group of people at RSMC and appreciated learning from different perspectives. She enjoyed organizing activities to celebrate diversity among campers. However, she felt that there weren't enough people of color such as Blacks and Hispanics during the time she attended camp. Even though this experience was valuable in being able to connect with different types of people, it wasn't very much different from her high school experience in terms of diversity. This experience did not end up confronting her original perception that she had prior to coming to RSMC that she was an exception among her community as a result of being good at math. This is a powerful finding and has implications for creating and maintaining a diverse student body at RSMC or any other informal learning space. However, Samara did acknowledge the invaluable experience she had at camp where the teachers and counselors were invested in her learning and cared about her future. She considers RSMC to be a life-changing experience. She credits camp for not only helping her find her true passion of computers and math but also for giving her the strength and starting points in life to recover from a negative experience in college and make a return to STEM.

Narratives of gender/race/class
<p><i>"it was suddenly galvanized that I was a black person who loved math, I was a [black] woman who loved math, and that was galvanized, because I was put up alongside such an overwhelming majority of people who liked Math Camp looked like, who Math Camp was. The average person didn't look like me... I was like, "Oh, I must be rare. I must be special."</i></p> <p><i>"every summer at Math Camp, I decided to celebrate [Juneteenth 00:19:14]...there were people who didn't really know what it was. I was like "Okay, I have to educate everyone in this space, so that [they] know what Juneteenth is and why it's important [...]. So, I would buy a watermelon and I would cook food, and I would encourage others to do a potluck kind of a thing and it was somewhat receptive to the general population and then, of course, to my cohort of friends. We all enjoyed it thoroughly!"</i></p> <p><i>"I also recall a couple of Sundays making breakfast tacos for whoever wanted some. Um, so I very much enjoyed the Hispanic identity that I had as a [Southerner]."</i></p> <p><i>"there was one particular summer where the custodian, the custodial staff in the building we were going to were all women, you know, the Hispanic woman. And I would always make a note to say, "Hi." I would go out of my way to say, "Good evening" um, and at the end of one summer, one of the women, she ran up to me and she was like "Oh, is this your last [day]?" And I was like "Yeah, I know, I'm leaving." She handed me a hand-sewn bag that I have to this day... that was so sweet, goodness gracious"</i></p> <p><i>"Every year I am able to connect with all kinds of people"</i></p>

Figure 38. Samara's MLI (narratives of gender/race/class) post RSMC

### The shift in Samara's MLI

Samara went from having a very narrow view of mathematics (*algebra and arithmetic; problems always having a fixed answer; math is a series of formulas*) and what it means to be successful in it (*solving problems quickly like a calculator; memorizing formulas; getting good grades*) to a much broader and realistic view of what constitutes the realm of mathematics (*a vast discipline; applications of math in different fields*) and what it means to be successful in it (*exploring, learning from different perspectives, persisting, pushing your limits, developing internal understanding, having a support structure*). Samara developed a set of study skills and motivation to persist in doing math when it became challenging. She learned at camp how to collaborate with others, learn from different perspectives, and have fun with her friends while solving problems. She also learned to deal with frustrations of getting stuck on problems, failure, and the discomfort that comes from working with a challenging curriculum for the first

time. She appreciated the support she received from her counselors and teachers who would push her to do more, stretch her mind, give her confidence to trust in her abilities, and take an interest in her future. Experiencing internal understanding, sharing it with peers and teachers, and mentoring the new campers to develop their own problem-solving skills was very rewarding for her. Camp became a place for her where her love for Math and other STEM areas such as computers came gushing out as she notes, “I started gushing about math the same way people gush about band camp... I guess it's -- like, not that it wasn't okay before, but I am realizing, I can now access this whole other side of me. Like, I love sci-fi, I love all of these other things, computers.”

The narrative on gender/ethnicity/class suggests that even though Samara could connect with a group of people different from her, she did long to have more campers who would look just like her. Perhaps seeing more black campers succeeding at camp along with her, Samara could have confronted her perception of being an exception.

### **Higher Education Trajectory upon leaving RSMC**

Did RSMC have any impact on the higher educational/career paths that Samara took? If so, what? To answer this question, I explored the construct of social capital in terms of the resources available to and accessed by the participant through social networks (e.g. parents, relatives, friends, acquaintances, peers, teachers, mentors, and organizations) before and after being a member of RSMC towards her status attainment (education/career) goals. This section describes the higher education/career trajectory that Samara envisioned for herself prior to RSMC experience and the shift that took place in this trajectory during RSMC. However, as noticed earlier Samara completed her undergraduate degree in African and African American Studies and is currently pursuing

her graduate studies in theology and tech literacy in order to become a computer chaplain. This begs the question - If Samara used to like math and computers as evidenced from the previous sections, then why did she choose to study interdisciplinary humanities? To answer this question, I inquired about Samara's college experience upon leaving RSMC. I will discuss findings related to her experience in college and the impact this had on her career/higher ed. trajectory. All the quotes that appear in this section are from the camp evaluations, correspondence, and the two interviews.

### **From a modest plan to a bigger dream**

In order to determine the impact of RSMC on Samara's SC and consequently on her higher education/career trajectory, I asked her to recall her career aspirations before coming to RSMC and describe if RSMC had any influence in realizing or changing those aspirations.

The following figures show examples of utterances from her interviews that lead me to conclude that before coming to RSMC Samara wanted to go to a small private Baptist College in her neighborhood and then get a job. This is as far as she dreamed based on the resources she accessed in her immediate social capital such as her family and friends. However, RSMC disrupted this trajectory for Samara by expanding her social network and making available to her resources that would open up a world of opportunities, broaden her horizons and her academic preparation, give her the confidence to dream bigger, and help her get on a path to realize her true potential.

Table 13  
*Samara's Pre-RSMC SC*

Before RSMC: education/career trajectory	Participant utterances	
Planned to attend a local college and get a job	<i>"so I, uh, my idea was to go to a really small private Baptist college in [my home town]"</i>	<i>"And yeah, uh, it was inexpensive, it was close to home, and I thought "Yep, I'm just going to hurry up and get through that and then hurry up and get a job and hurry up and die so I can go to heaven." That was my life plan, it was that big."</i>
Limited social capital and motivation	<i>"Well, my family was pretty low social economic status and so they were just urging me to get a good job. Get a good job"</i>	<i>"There wasn't much beyond a particular career or a path"</i>
Limited social capital and lack of role models kept from dreaming bigger	<i>"Um, so many of the people that were in my family or people that I knew that were adults were just trying to make it."</i>	<i>"they had a lot of blue collar jobs or lower positions that they would just hold for years and years. Custodial positions, home caregivers, these kinds of things."</i>  <i>"My friends were also sort of growing up in the same kind of community."</i>

Table 14  
*Samara's during/post-RSMC SC*

During/Post RSMC: education/career trajectory	Participant utterances		
RSMC significantly improved my academic preparation and brought out my passion for math and computers	<p><i>"They [teachers] also talked to me about my college choice and encouraged more from me"</i></p> <p><i>"everybody was encouraged to research things, for opinion"</i></p>	<p><i>"It [camp] certainly completely blew the lid off of my, uh, understanding of what math was..."; "I recall trying to think of something that I could solve, like I am trying -- I literally was trying to figure out a [...] PhD dissertation kind of topic of what I, as a fifteen-year old"</i></p>	<p><i>"it wasn't until after Math Camp that I started gushing about math the same way people gush about band camp... I guess it's -- like, not that it wasn't okay before, but I am realizing, I can now access this whole other side of me. Like, I love [...]computers"</i></p>
RSMC pushed me to realize my potential	<p><i>"expose you to these concepts to push you, to force you outside of your mathematical comfort zone, your intellectual comfort zone, your social comfort zone"</i></p>	<p><i>"I think being able to go through that process [...], was a really formative thing. And something that can be the foundation of [...] Being in college. Taking on research projects. Um, and really pulling all of your energies into something like that."</i></p>	<p><i>"...that conversation, um, really jostled my entire understanding of my capabilities and my capacity."; "Being surrounded by so many intelligent people, I get to meet all kinds of [...] perspectives. I feel I am able to do more as a person and I am able to stretch my capabilities"</i></p>
RSMC expanded social capital	<p><i>"I was very impressed by the fact that there was all these young people, [...] they were going to these amazing schools, but</i></p> <p><i>they're also really down to earth. So, it was a great insight into what I could do, like introduce it into my experience and into my possibilities... Um, things that I hadn't considered before"</i></p>	<p><i>"[Mark] writing a letter of recommendation for me"</i></p> <p><i>"About this in particular, I think they [counselors] were usually trying to sort of see where our head was and just generally be encouraging."</i></p> <p><i>"I wouldn't have had the starting points that I did without Math Camp"</i></p>	<p><i>"I would say that I knew more people just by the pure essence of going through the program"</i></p>

Table 14 Continued

RSMC gave me role models to follow in STEM areas	<i>"It wasn't until math camp where there was the real presence of students who were in college, studying these things to do something with them for their future."</i>	<i>"That I could do that too. I could major in mathematics or major in engineering, something along those lines and actually do something with it"</i>  <i>"I was ... going to do engineering, um, [inaudible 00:10:30] engineering or computer science"</i>	<i>"the thing that stood out to me in first summer was that my counselor who was uh, [Salma Garcia], I think, she was a student at [University C] and she was also [from a small town predominantly Hispanic] ... I remember seeing her at [University C] and being like, "You! You are part of the reason I am here"</i>  <i>"...that conversation, um, really jostled my entire understanding of my capabilities and my capacity."</i>
RSMC broadened horizons and gave confidence to dream bigger	<i>"he [Mark] asked me where I was going and I told him that and he was like "I'm sure [xyz college] is a great school, I'm sure that wherever or whatever that is, but you need to be applying to Harvard or Stanford or [...] apply to Rice. If you want to go to, uh, Christian college, go to Baylor --."</i>	<i>"So, I was like "Okay [Mark], for you, I'll just apply, sure." And I applied to [University C], and I graduated from [University C], and that whole experience and, um, my life trajectory was augmented and changed forever because of that conversation with [Mark]."</i>	
RSMC experience helped me to come back to my original passion for computers after a negative experience in University C that marginalized me from it.	<i>"I'm coming full circle. Now, I'm tangentially related to the STEM field and my passion for it and still wanting to be involved in it, empower people in that space. Um, so, it has continued to reverberate and effect my perspective on the situation. And I think in a way that I wouldn't otherwise if I hadn't ever been to math camp."</i>	<i>"I'm now formulating this intersection between technology and theology...tying things back to my Math Camp experience. I mean, I wouldn't have had the starting points that I did without Math Camp... So, um, I feel like I'm ecstatic to see that Math Camp is still going."</i>	<i>"So, I always feel like I want to be the person to pay that forward and, and speak into people's existence good things like they will be able to see themselves."</i>

The quotes above illustrate that RSMC had a crucial impact on Samara's higher education/career trajectory, aspirations, and the decisions she made regarding applying to

some of the top-ranked institutions of higher learning as well as choosing a major. In this way, RSMC altered the course of Samara's educational/career journey by helping her discover her love for computers and giving her the starting points which later help her recover from a negative experience at University C and make a return to STEM. We may note from the perspective of this participant how access to and use of embedded resources in RSMC enhanced Samara's chances of attaining better statuses with respect to higher education and career related decisions.

### **RSMC practices valued by the participant and suggestions for improvement**

What practices and components of RSMC does Samara value and credit, if any?

In this section I identify particular practices that Samara values and mentions either in her past documents or in her recent survey and interviews. These are some of the practices/components of RSMC that led to the impact, discussed earlier, on Samara's MLI and SC. The following figure shows excerpts from Samara's past data sources in which she mentions aspects of camp that she likes or appreciates.

RSMC Practices/Components Valued	Participant utterances	Data Source
Teaching practices (providing support and encouragement, allowing you to take ownership of your work, having high expectations, interested in your future, productive struggle, deep understanding) at RSMC	<p><i>"[Edmund] is a very gentle teacher"</i></p> <p><i>"[Edmund] was available and ready to answer questions"</i></p> <p><i>"They [teachers] also talked to me about my college choice and encouraged more from me"</i></p> <p><i>"everybody was encouraged to research things, for opinion"</i></p> <p><i>"I like the attitude of the class [number theory]: here is a problem let's explore it"</i></p> <p><i>"[Dan] and his wife ... offer help in a way that does not spoil a problem for you"</i></p>	Data Source: Camp evaluations, 2003
Camp Curriculum	<p><i>"I got to understand more and even learn the new topics"</i></p> <p><i>"I started liking Mathematica as I liked learning an introduction to Visual Basic"</i></p> <p><i>"I loved honors seminar. The topics were deep and intellectual and not all about mathematics. I learned about different types of intelligence and some good books to read...If I could, I would also want to take that class again as a second year"</i></p> <p><i>"That [musical and graphical aspects of Mathematica] along with lava lamp and rollercoaster sets, encouraged me to explore Mathematica for myself"</i></p>	Data Source: Camp evaluation, 2003
Study groups (bonding, learning through discourse and collaboration, appreciating different perspectives, enjoying learning)	<p><i>"Camp teaches me to work with different kinds of people. Being surrounded by so many intelligent people, I get to meet all kinds of opinions and perspectives. I feel I am able to do more as a person and I am able to stretch my capabilities"</i></p> <p><i>"The opportunity to explore ideas and opinions for myself and from others helped me to get comfortable thinking about different types of concepts."</i></p>	Data Source: Camp evaluation, 2003

Figure 39. RSMC components valued by Samara as noted in her past data sources

RSMC Practices/Components Valued	Participant utterances	Data Source
Camp Counselors ( <i>help received from her counselors as well as being a counselor herself</i> )	<p><i>"She [counselor] would have us go through a problem despite gripes and complains. She brought us food twice a week and joked around with us. I felt comfortable talking to [Betty] because she was an honest and light hearted person"</i></p> <p><i>"I understand everything [Cory] talks about...He comes during our study group and helps"</i></p> <p><i>"I also managed a friendship based relationship [with campers] so that they feel comfortable enough with me to tell me problems they may be having"</i></p> <p><i>"I feel my best quality as a counselor is my interpersonal intelligence. I like teens....so I enjoy making and nurturing the relationships"</i></p> <p><i>"A comradery, foundation of acceptance, and trust ...allows me to best relate to campers"</i></p>	Data Source: Camp evaluations, 2003, 2004
Colloquia ( <i>Experiences exposing to STEM ideas. Female speakers in STEM mentioned</i> )	<p><i>"her [Sarah Cole] love for her job showed through the presentation and helped us understand the work of an engineer more"</i></p> <p><i>"[Jenny Cho] ...her problems were intriguing and made me think outside of anything I knew before"</i></p> <p><i>"[Delores Fernandez] ...her talk helped me understand the mathematics behind [internet] searches and helped me to better my own searching"</i></p>	Data Source: Camp evaluation, 2003
Social aspects at RSMC ( <i>weekend trips, socializing with peers, sharing new experiences, exposure to outside world</i> )	<p><i>"Last summer was the first time I had ever canoed. If not for math camp, I would never have done it"</i></p> <p><i>"the service project...picking up rocks to build a dam was practical...the overall experience was enthusing and inspiring"</i></p> <p><i>"weekend and rec activities provide me with things, I could never do at home"</i></p>	Data Source: Camp evaluation, 2003

Figure 39, Continued. RSMC components valued by Samara as noted in her past data sources

When asked in the recent interviews about the practices/characteristics or elements of RSMC that Samara came to value, she identified the following – *examples of ambitious and successful people who are also down to earth, colloquia, support and encouragement from the camp director, help received from camp counselors, the six week residential aspect of camp, feeling of acceptance and welcome from the camp staff and counselors, camp curriculum, teaching practices (such as time to explore the problems for deep understanding, helping you deal with failure, helping you go through something challenging to build confidence, encouragement and support), and social aspects such as weekend trips* as most significant for her.

Regarding being surrounded by people who were ambitious, successful, and down to earth, Samara stated “I was very impressed by the fact that there was all these young people, *some of which who looked like me or similar to me*, and they were going to these amazing schools, but they're also really down to earth. So, it was a great insight into what I could do, like introduce it into my experience and into my possibilities.” Being a part of RSMC community expanded Samara’s horizons and gave her role models in peers and counselors. This experience gave Samara the confidence to dream bigger and pursue her interests. Samara also valued the colloquiums every Friday where guest speakers from different fields were invited to give a talk and interact with the campers afterwards during an informal picnic gathering. Samara recalled in her interview the importance of these seminars “I did appreciate the individuals who came in every Friday because it was really a good experience to connect math camp, math in general to the outside world... They do give people a vision of what they can have.”

Regarding the support and encouragement that she received from her camp teacher Mark Weitzman, Samara felt that Mark was invested in her future and took the time to counsel her about applying to some of the best schools for higher education to pursue her interest. She stated “my life trajectory was augmented and changed forever because of that conversation with [Mark]... that conversation, um, really jostled my entire understanding of my capabilities and my capacity.” In one of Samara’s correspondence with Mark from 2005, I found the following comments from Mark, in which he continues to build her confidence and show support

You continue to grow and mature. Not only are you amazing at dancing, but you are one of the most articulate campers we have ever had. You should never feel defensive about getting into [University C]—they accepted you because of your abilities in many areas. Many students think that the only measure of a person is an SAT score, but there is so much more. You have the whole package.

It is this kind of support and encouragement from Mark that Samara finds so life changing and values even today.

In hindsight Samara considers the six-week residential characteristic of the camp to be important in having a formative impact on campers. She considers this practice to be essential for campers to learn about commitment, grow independent and stronger in a sheltered and supportive environment. Staying away from home on a college campus gives campers a sense of what college might be like and gives them the confidence to think about going off to college for higher education. The following quote from Samara conveys how valuable she considers this practice of camp

Well, one thing that was really unexpected is the ability to be away from home at that age for so long. That experience in and of itself is really maturing in a lot of ways. So to have that experience so young is a really big victory to have or success to have under your belt already... Um, so just the fact that it was a stay-away and that is was so long. It was the duration of that entire Number Theory class. So it was a commitment and I think being able to go through that process and devote that much time to something at that age, was a really formative thing. And something that can be the foundation of going off and doing more things similar to the set-up there. Being in college. Taking on research projects. Um, and really pulling all of your energies into something like that.

Samara finds the counselor mentorship, teaching practices, and curricula of the camp to be important components of RSMC. She appreciated how teachers and counselors would help the campers discover the solutions to the problems themselves, push them to persist, and encourage them to collaborate. She mentioned in her interview that the teachers at camp “expose you to these concepts to push you, to force you outside of your mathematical comfort zone, your intellectual comfort zone, your social comfort zone.” Teachers at camp expose the campers to quite challenging curricula and through the process of going through these challenges help campers learn how to deal with failure, develop persistence and confidence. Samara mentioned that teachers “give you a series of experiences of failures, so that you could have them out of the way...Um, to give you an opportunity to do something you didn’t think you could do.” She recalled that when she was at camp one summer she “literally was trying to figure out a mathematical PhD dissertation kind of topic” at the age of fifteen. She appreciates being

exposed to the challenging curriculum at camp to get a more realistic understanding of what constitutes the field of mathematics. She mentioned “It [camp] certainly completely blew the lid off of my, uh, understanding of what math was ... it was completely far field from anything I had ever done before...So, I feel like, um, that was such a huge takeaway, just to see so much more of the field.” She values the ideology behind the “pedagogy of Math Camp” to empower the students who might not otherwise think of themselves capable of handling something challenging or even going to college. Samara recalled her first year counselor with much fondness during our interview as she mentioned

my first counselor, [Salma]! I loved that she was a math person, but she also had all these other fast-starts. So, she completely broke the mold of what it meant to be a counselor to me... she exposed me to Simply Orange, orange juice. She brought it to the session one evening, and I still drink it to this day and um, like, little things like that make such a huge difference... I remember seeing her at [University C] and being like, “You! You are part of the reason I am here.

Samara had good things to say about her other camp counselors as well such Cory Parson, with whom she still keeps in touch via Facebook. Samara considers counselors to be an important component of math camp that play a big part in determining the kind of experience a new camper might have at camp especially during their first year. She mentioned, “a camp counselor embodies a lot what your experience is going to be like. So, their personality, their attitude, the way that they, um, approach their position can really make a difference to whether or not you feel like you fell through the cracks, whether or not you, um, feel like your experience was enjoyable in some ways.”

Regarding the sense of a friendly and welcoming community, Samara stated that RSMC creates an atmosphere where students feel welcomed. Professors, counselors, and even camp staff make an effort to be friendly to the campers and invite campers to eat lunch with them. She recalls “there were some professors or counselors that did act like really good friends with some of us. So that was also a community of itself. I remember mentioning before about how having lunch with some of the staff... When I was a camper. It was really great to sort of see their perspective of the experience and be able to share the experience and get to hear sort of about what was going on in the back-end, if you will... I really enjoyed having lunch with the staff.”

Samara also values the social aspects of the camp. In her interview she stated, “I also enjoyed the trips... So being able to go to the mall or go to [the hiking place] or go to [the ranch] or, I think we went bowling... we did do several different things throughout the summer that took us off campus as a group.” She valued this practice of bonding with peers in a non-classroom setting by sharing new experiences, which led to broadening her interests and learning how to socialize with a diverse group of students. Furthermore, “the picnics every Friday were also a time of rest and respite” from “the 4 hour problem sessions... which were very intense” that the group would be working on through the entire week. She recalled looking forward to the picnics every Friday. Samara also mentioned bonding with her peers during study sessions and recalls that “so some of us would either go/sneak off to the arcade and play video or whatever.” She also mentioned that “Um, there's a lot, there's a lot of stories about romance at Math Camp, I think there is a couple of Math Camp couples who are, maybe, they came out of that experience.”

At this point Samara also mentioned a negative experience she had with a former peer from math camp. She recalls that there was this “one individual who, [she] was convinced at the time, didn't like” her. She recalled that one summer, New York Times was doing an article on RSMC at a gala. She and a few other campers were selected by the reporters to share their experiences. She recalled overhearing this camper, who was an Asian boy, remark that Samara was selected by the reporters because she was Black and a girl. However, Samara chose to ignore his remark but she did feel hurt. Years later Samara ended up running into this same individual at her college. This individual then told Samara that the only reason she got into University C was because she was Black and a girl. Furthermore, he accused Samara of “taking a space at [University C] that could have gone to his White friend who deserved to go but was not a woman or a person of color.” It seemed like that this one individual either had something against Samara in particular or women and black community in general. At this point I asked Samara what she could suggest as improvements for RSMC so that the camp community can do a better job at educating campers about issues of race and gender. Samara suggested that increasing the “number of certain minorities and women” from minority backgrounds when recruiting campers would be a huge improvement. She also noted that although RSMC tries to convey the message to address “some of the dynamics within the campers, um, some norms and standards and expectations” that “everyone here is here for a reason and has something valuable to contribute and that we're all existing on a spectrum. No one place on that spectrum is better or worse.” However, there were some campers among who existed a culture of placing value on the intellect. Samara mentioned among some campers there is “this value that was placed on intellect and smarts and this

pecking order of okay, this is the smartest person and these are the people that are in their range and then these are the other.” She stated that she doesn’t quite know how the teachers, counselors, and staff at the camp would dismantle this notion that may exist in some campers. However, she suggested that perhaps a message that comes from Mark (because he is the director and everyone looks up to him) that conveys the vision of camp would be very powerful. She mentioned in the interview “I think if you're one of these people who has a chip on your shoulder about women or people of color in math, [Mark] sits down and tells everybody kind of the statistics or talks about the issues that other people face. Just getting people to the other side of the coin, I think that would be huge. Or to build that in some how.” Another suggestion was to include more talks about “The history of women or the history of people of color” in math or other STEM areas.

### **Summary of RSMC practices valued and suggestions for improvement**

Some of the same practices that were valued by Samara when she was a high school student attending RSMC were also valued by her in her recent retrospective interviews. The figure below summarizes Samara’s valued practices about RSMC from the past and the present. The highlighted cells indicate the common ones. These are elements of RSMC that led to the impact on Samara’s MLI and higher education/career trajectory overtime.

Table 15

*Summary of RSMC practices/components valued by Samara*

RSMC Practices/components valued in the Past (while attending camp during high school)	RSMC Practices/components valued in the Present (in retrospect)
Teaching practices ( <i>providing support and encouragement, confidence, allowing you to take ownership of your work, having high expectations, interested in your future, productive struggle, deep understanding</i> ) at RSMC	Teaching practices ( <i>teaching you how to deal with failure, stretching your limits, developing confidence, persistence, deep understanding, providing support and encouragement, having high expectations, productive struggle</i> ) at RSMC
Camp counselors ( <i>help received from her counselors as well as being a counselor herself</i> )	Camp counselors ( <i>help received from her counselors</i> )
Study groups ( <i>bonding, learning through discourse, collaboration, and diverse perspectives</i> )	Mentorship from the camp director at RSMC ( <i>invested in your learning and future, provides help, support, encouragement, instills confidence</i> )
Social aspects at RSMC ( <i>weekend trips, picnics – trying new things, exposure to the outside world, socializing and bonding with a diverse group of peers, broadening interests</i> )	Social aspects at RSMC ( <i>weekend trips, picnics – trying new things, exposure to the outside world, socializing and bonding with a diverse group of peers, broadening interests</i> )
Camp curriculum ( <i>challenging and interesting, Mathematica, Combinatorics, Number Theory, Honors Seminar</i> )	Camp curriculum ( <i>challenging and interesting, Mathematica, Combinatorics, Number Theory, Honors Seminar</i> )
Colloquia ( <i>Experiences exposing to STEM ideas. Female speakers in STEM mentioned</i> )	Colloquia ( <i>Experiences exposing to STEM ideas.</i> )
	The six week residential aspect of camp ( <i>commitment, independence, strength</i> )

Some of the suggestions offered by Samara for improvement to address the issues of gender and race include – recruiting more campers from certain minorities such as Blacks and Hispanics and more women campers from these minority groups, having the director of the camp more formally convey the equity oriented vision of the camp to all campers, and inviting speakers who highlight the history and contributions of women and people of color in math and other STEM areas.

### **Case Summary with respect to the research questions**

According to Samara RSMC played a significant role in changing her perceptions about learning math and herself as a learner of math. Samara went from having a very narrow, rote, and non-creative view of mathematics and what counts as success to a much broader and realistic view of what constitutes the realm of mathematics and what does it mean to be successful in it. Samara developed a set of study skills and motivation to persist in doing math when it became challenging. She learned to deal with frustrations of getting stuck on problems, failure, and the discomfort that comes with working with a challenging curriculum for the first time. She also learned to collaborate with others, learn from different perspectives, and have fun with her counselors and peers in the process of learning. She appreciated the support she received from her counselors and teachers who would push her to do more, stretch her mind, give her confidence to trust in her abilities, and take an interest in her future. Experiencing internal understanding, sharing it with others, and mentoring the new campers to develop their own problem-solving skills was very rewarding for her. Furthermore, camp became a place for her where her love for Math and other STEM areas such as computers came gushing out.

RSMC had a crucial impact on Samara's higher education/career trajectory, aspirations, and the decisions she made regarding applying to some of the top-ranked institutions of higher learning as well as choosing a major. In this way, RSMC altered the course of Samara's educational/career journey. We may note from the perspective of this participant how access to and use of embedded resources in RSMC enhanced Samara's chances of attaining better statuses with respect to higher education and career related decisions. Before coming to RSMC Samara didn't know what she wanted to pursue as a

career. Her parents wanted her to get a job. So, her plan was to attend a local community college and “hurry up and get a job”. However, RSMC disrupted this trajectory for Samara and had a crucial impact on her higher education/career aspirations and the decisions she made regarding applying to some of the top-ranked institutions of higher learning as well as initially choosing a major. Through her own experiences as a camper at RSMC, Samara found her true passion for computers and math. This is when she first decided to pursue her studies in computers and engineering. Being surrounded by peers and counselors who were ambitious and successful, and “some of whom looked like her”, Samara expanded her horizons and learned to dream bigger. She developed confidence in her own capabilities and through the guidance and encouragement from teachers and counselors, Samara decided pursue her interests and apply to some of the top-ranked institutions of higher learning. Samara credits RSMC experience from recovering from a set back she faced in college (discussed in detail in the next section). After deciding that STEM areas were not for her owing to a negative experience in college, Samara was finally able to return to her original interest in computers and is now pursuing a graduate degree in theology and tech literacy at a Seminary affiliated with an Ivy League University. She plans to become a computer chaplain, where she will empower people in this Christian space by teaching them about problem solving and digital citizenry. Samara mentioned in her interview “I’m coming full circle. Now, I’m tangentially related to the STEM field and my passion for it and still wanting to be involved in it, empower people in that space. Um, so, it has continued to reverberate and effect my perspective on the situation [the negative experience at University C that marginalized her from completing a degree in computer science]. And I think in a way that I wouldn’t otherwise if I hadn’t

ever been to math camp.” Samara explained to me that she feels that she has found a way to connect her two interests theology and STEM “I am not necessarily looking to be a traditional pastor, but I am now, um, speaking about the passions that I have with STEM, specifically computer science and problem solving, like an engineer and serving people, um, like a minister, like a pastor, in those spaces.” She credited RSMC for giving her the starting points in life through which she is now able to make a come back to her original passion in STEM. She mentioned “So, I'm now, just now formulating this intersection between technology and theology in this way, which is -- it seems super new... I feel like tying things back to my Math Camp experience. I mean, I wouldn't have had the starting points that I did without Math Camp... So, um, I feel like I'm ecstatic to see that Math Camp is still going. I would love to continue to speak into that experience and group.”

The particular practices and components that Samara came to value over time as mentioned either in her past data (essay, evaluations) or in her recent, survey and interview include

- Teaching practices (*teaching you how to deal with failure, stretching your limits, developing confidence, persistence, deep understanding, providing support and encouragement, having high expectations, productive struggle*) at RSMC
- Camp counselors (*help received from her counselors as well as being a counselor herself*)
- Colloquia (*Experiences exposing to STEM ideas. Female speakers in STEM mentioned*)

- Camp curriculum (*challenging and interesting, Mathematica, Combinatorics, Number Theory, Honors Seminar*)
- Mentorship from the camp director at RSMC (*invested in your learning and future, provides help, support, encouragement, instills confidence*)
- The six week residential aspect of camp (*commitment, independence, strength*)
- Role models (*examples of ambitious and successful people who are also down to earth*)
- Study groups (*bonding, learning through discourse, collaboration, and diverse perspectives*)
- Social aspects at RSMC (*weekend trips, picnics – trying new things, exposure to the outside world, socializing and bonding with a diverse group of peers, broadening interests*)
- Sense of a friendly and welcoming community at RSMC (teachers, counselors, staff socialize with campers)

Some of the suggestions offered by Samara for improvement to address the issues of gender and race include – recruiting more campers from certain minorities such as Blacks and Hispanics and more women campers from these minority groups, having the director of the camp more formally convey the equity oriented vision of the camp to all campers, and inviting speakers who highlight the history and contributions of women and people of color in math and other STEM areas.

### **Additional Findings: So, what happened in college?**

Upon leaving RSMC Samara was set on her path to become an engineer or computer scientist by pursuing her undergraduate degree in Computer Science and Mathematics at one of the top-ranked schools in the US. So, what happened in college that made her switch majors and leave the field of mathematics altogether? The script below from my interview with Samara illustrates the challenges and subtle discriminatory situations she faced during her first year at college.

Samara: Well, I think the situation, the one I was talking about before where I was in this really high level math class my freshman year. I was 1 of 2 people of color. I was 1 of 3 women. By the end of the week, I was the only person of color. By the end of 2 weeks, I was like 1 of 2 women. This was a class of 40 individuals. Predominantly white/Asian men and the entire situation I thought was extremely grating on my confidence in myself.

Samara: So in this class, I very much felt like my identity was being distilled into my gender and my race. I, there's this thing known as the black tax where you have to work twice as hard to get half as much of your non-black counterparts. I think that could be the case for people of color, for women. Your expect ... The expectations of you are going to be either lower because you're a woman or a person of color or really high, like "you need to be at least this good to even get my attention."

Samara: So dealing with that kind of pressure and stress, no one really ever said anything to me. These things aren't exclusively said. They're really subtle. The study groups that happened, no one ever asked me to join a study group. Like, for me to go and approach people and get to know people ... As I was learning just how to be a freshman and the whole college experience was unfolding at that exact same time, I felt like there was a lot of moving pieces and I didn't really have an in. I felt like if I was a white guy, somebody would've asked me to be in their study group, no question at all.

Samara: I think that I don't know how else I could've gone through that experience like what I could've done differently besides like trying to find a mentor, reach out to some of the other women.

Samara: Or, trying to talk to the professor didn't seem like something that would make sense...I don't think I could have articulated my issue and my experience to him...Um, and then initiate a conversation like that in his face like that, I would be thought of someone who needs help. I'm the one that needs a handout or I'm the one that you know or whatever the case.

Samara: So that kind of being put on my personality or my identity, I didn't want to take that on. And so not asking for help from certain individuals and [not] knowing how to ask for help. I really felt that experience ingrained in me that maybe this isn't for me, that maybe this isn't something I can do and so I went on to non-math related degrees.

Samara: Um, and I feel like if I had a support system of some sorts, uh, then I might be an engineer today, or I might be a computer scientist.

From the script above we may note that Samara had a negative experience in one of advanced math classes she took as a freshman in college. Samara felt intimidated in a setting in which she was the only person of color and one of two women in a class of 40 students. Her peers did not include her in any of the study groups and her professor or her TA didn't reach out to her either. Although no one said anything to her directly, but what the actions of her peers, professor, and TA communicated, amounted to discriminatory practices in subtle ways. Having limited social capital at home, not knowing how to articulate her experience to her professor and not wanting to be labeled by her peers as a person who needs a "handout" for asking for help, Samara did not know who to turn to for guidance and felt helpless. This experience ingrained in Samara that STEM was perhaps not a field for her. By excluding Samara and not reaching out to her or guide her and offer support, a community at University C certainly played a major role in marginalizing this young black girl from a field she considered to be her passion. Samara switched to a non-STEM major and graduated from University C with an undergraduate degree in African and African American Studies. Upon graduation Samara moved to the east coast to work for AmeriCorps. It was there that she got involved with a faith community and wanted to understand more about her faith and her community. Her pastors encouraged her to consider a career at a seminary and help people through that. Finding strength in her faith and wanting to make a come back to STEM, Samara decided

to pursue a graduate degree in theology and technology literacy at a Seminary affiliated with an Ivy League university. She plans to become a computer chaplain, where she will empower people in this Christian space by teaching them about problem solving and digital citizenry. Samara mentioned in her interview “I’m coming full circle. Now, I’m tangentially related to the STEM field and my passion for it and still wanting to be involved in it, empower people in that space. Um, so, it has continued to reverberate and effect my perspective on the situation [the negative experience at University C that marginalized her from completing a degree in computer science]. And I think in a way that I wouldn’t otherwise if I hadn’t ever been to math camp... That’s kind of how I’ve been able to come back around to it [STEM] from that.” The experience at University C may have marginalized Samara from completing an undergraduate degree in computers, however owing to her inner strength, determination, and her love for STEM, she is able to make a come back to her true passion.

### **Cross-Case Analysis**

The above sections presented the findings of the study through four embedded-case reports. Each report was divided into three sections: MLI co-construction and shifts, Higher Education Trajectory upon leaving RSMC and RSMC characteristics/practices valued by the participant. In this section I will present the findings of the four participants analyzed as a group. These findings are also divided into the aforementioned three sections that correspond to the three research questions for this study. The findings across all four cases present a comparison of similarities and differences in the views of the participants that have implications for learning settings.

## **MLI co-constructions and shifts**

### **Perceptions about Mathematics as a discipline and learning math**

All four participants described a narrow and limited view of mathematics and its learning prior to RSMC experience. All four participants described mathematics as either a “bunch of numbers or equations” with “no practical application”, “series of formulas”, “problems...that always had one exact answer” and one fixed way to solve them, non-creative field, or “algebra and geometry.” Each participant thought that doing or learning mathematics meant memorizing procedures and rules given by the teacher to get a high score on the test. All four associated speed and getting to the “right answer quickly” with doing math. While Anahi, Hima, and Mira described math as a solitary activity, Samara described it as a process of “performing functions like a human calculator.” For Anahi and Hima being successful in Math also meant competing against their peers. All four saw mathematics as rote and teacher-driven. However, upon attending RSMC, all four participants mentioned that the camp experience helped them develop a much broader and realistic view of mathematics as a discipline and learning or doing math.

### **Perceptions of self as a learner of Mathematics**

All four participants considered themselves as excellent students of mathematics prior to RSMC. This perception was based on succeeding in the practices of their respective school environment, which according to these participants mainly focused on getting good grades on exams, paying attention in class, doing homework, memorizing procedures and formulas to find the correct answers to the problems, being fast at solving problems, and maintaining a top-rank in class by competing against your peers. All four participants took a hit to their positive self-perceptions as a learner of math during the

first year at camp as their conception of mathematics and learning was being shaken by the practices of RSMC which valued thinking, questioning, collaborating, and deep understanding over speed, memorizing, grades, and compliance. RSMC made various identity resources available to the participants such as a sense of a collaborative and supportive community, teaching practices that give more agency to the students, study groups, camp counselors, mentoring by the camp director, the practice of journaling, etc. All four girls reported the impact of these practices in varying degrees on their identity development. The camp experience on the whole led to a deeper understanding of learning and themselves as learners among all four participants. As a result all four participants became more connected to the practice of Mathematics and developed broader and holistic learning identities in the context of math and STEM.

### **Narratives of gender/race/ethnicity/national origin/class**

Prior to RSMC, three of the four girls, Anahi, Mira, and Samara subscribed to deficit views about their race, ethnicity, gender, or social status when it came to learning math. They saw their gender, class, and ethnicity as constraints. The fact that they were considered academically good in their schools made them think that they must be an exception to what is considered the norm within their community. Samara even had a hard time at home, where her family accused her of *acting white* by being good at school. On the other hand Hima bought into the stereotype that she is naturally good at math on account of being from China or being Asian. The way she was treated in her middle school and high school by her peers and teachers served to reinforce this stereotype in her. However, for three of the participants these stereotypical views were disrupted after the RSMC experience. Upon attending RSMC, we see that Anahi found in her counselor

Mira the role model of a Hispanic woman who was successful in a diverse setting. Unlike her earlier perception where she thought being Hispanic from a low-income family was a constraint to being successful and had something to do with one's *ability* to learn and succeed, having found a counterexample in her counselor Mira, Anahi no longer subscribed to that view. She came to believe that Hispanic women from low-income families can be successful in diverse settings and being such a woman herself, she could be successful too. She no longer felt that she was an exception. This suggests that her finding a successful role model in a person of same gender, class, and ethnic background was crucial to her confronting the 'storyline' she previously believed.

Mira credited the sense of community that she experienced at RSMC in helping her confront her previously held views about who is capable. She saw herself as part of a community where

- diversity was valued;
- people were accepted for who they were; and
- a belief that everyone irrespective of their background has something unique to offer and can learn math through hard work was upheld.

By seeing herself and others succeed in a diverse environment through hard work and support of the people, Mira came to believe that a person's race, ethnicity, gender, or class has nothing to do with their ability to learn. Anyone irrespective of their background can be successful through hard work and by being part of a community that supports and values diversity.

For Hima it was the diverse group of peers that she met at RSMC, who helped her confront her stereotypical views. She made the following comments in her past journals and in a recent interview:

“after getting to know so many super intelligent and talented people at camp, I realize in so many ways they are just like me”

“... You open your eyes to, like, what people really know, ... you do [get] exposed to a wide range of smart people. I think that's a really good thing. Like, you know, for people, when they grow up”

The above comments suggest that by being in the RSMC environment where she met a diverse group of peers who were just as knowledgeable as herself helped her break through a previously held notion about being naturally good at math just because she was from China. It seems that she came to the conclusion that the properties of national origin had nothing to do with one's abilities to understand and learn math.

For Samara the RSMC experience helped her to connect with a diverse group of people and she appreciated learning from different perspectives as well as being supported by her teachers and counselors. She learned that she could succeed at math or any other field through hard work and perseverance. However, this experience did not end up confronting the original perception that she had prior to coming to RSMC that she was an exception among her community as a result of being good at math. Samara reported a lack of Black campers at RSMC during the time she attended camp as well as reported a negative experience she had with a peer at camp. However, Samara did acknowledge the invaluable experience she had at camp where the teachers and counselors were invested in her learning and cared about her future. She considers RSMC

to be a life-changing experience for her and credits camp for helping her find her true passion.

All four participants displayed a narrow and ritualized Pre-MLI in a procedure driven figured world of their respective school environments. Upon attending RSMC, all four participants developed a broad and holistic understanding of the field of mathematics, learning, and themselves as learners of math. Three of the participants were also able to confront their previously held stereotypical views about race, gender, national origin, and/or class in the context of learning math. How did the RSMC experience help create these shifts in participants' MLI? We find from the perspective of the participants that various identity resources were offered to them through camp components and practices such as mentorship from the camp director, teaching practices that give agency to campers, help and mentorship from the counselors, learning through study groups, challenging and interesting curriculum among others. All four participants' MLI was influenced by the interactive relationship between them (what they brought to the interaction) and the opportunities afforded to them by RSMC as a result of this interaction. Connections between self and the activity of learning math were fostered through these interactions. In other words, practice-linked identities were made available to the participants in this study and were taken up by these participants in different ways. These findings help answer the first research question of this study from the perspective of the participants about how RSMC influenced the development of their MLI.

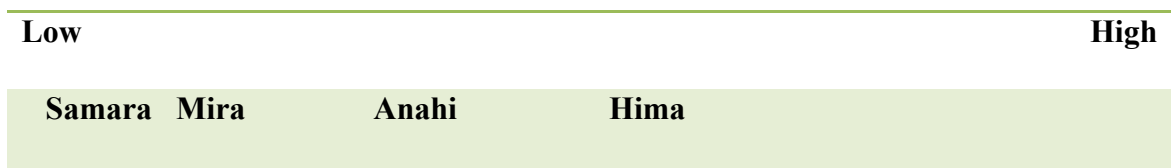
### **Higher Education Trajectory upon leaving RSMC**

Recall that the construct of social capital (SC) is used to study the impact of RSMC on higher education and career trajectories of the participants. This construct is

explored in terms of the resources available to and accessed by the participant through social networks (e.g. parents, relatives, friends, acquaintances, peers, teachers, mentors, and organizations) before and after being a member of RSMC towards her status attainment (education/career) goals. In the context of this study, I have used the definition of social capital provided by Lin (1999) who defines it as resources accessed in social networks that depend upon human capital (self/parental education and experiences), initial positions (parental or prior occupational statuses) and one's social ties (e.g. kin, friends, acquaintances, colleagues, organizations).

All four participants reported varying degrees of limited social capital prior to coming to RSMC. All four reported financial constraints being a factor to consider in even thinking about an expensive university as well as reported a lack of female role models before coming to RSMC. Furthermore, Samara's family accused her of acting white because she was considered good at math. She had a difficult time maintaining her identity as a black woman and a person who was considered good academically. Mira and Samara's families did not support the idea of going to a big university. Samara's family wanted her to get a job after high school while Mira's family supported the idea of her attending a local community college on account of her being a girl. Because Mira was a girl, the family expectation was that she should stay close to home. Anahi was also planning to attend a local community college because in her circle of family and friends everyone stayed close to home. Mira, Samara, and Anahi all reported that their parents had some high school education or had completed high school. These three girls also reported that they attended "overcrowded", "underrepresented" schools in "poor neighborhood[s]", where there was a lack of guidance about pursuing higher education or

career choices and a general lack of motivation among peers who were just trying to graduate high school. On the other hand Hima reported that her parents had already planned her future in which she was to pursue higher education in computer science or math. Hima's family did not respect her choices and she received no encouragement from her family to figure out her own interests with regards a career path. The figure below shows the four participants on a spectrum of limited social capital relative to each other.



*Figure 40.* Pre-SC of all 4 participants relative to each other

Upon attending RSMC we may note that each participant's SC was affected through the interaction between the participant and the components of the RSMC environment such as peers, counselors, and teachers. For all four participants the most significant factor influencing their SC was the mentorship they received from the camp director in considering top-ranked schools for higher education, the confidence he displayed in their abilities as a whole person, and the guidance he offered. Other factors that impacted the participants' SC included finding role models among counselors, teachers, and guest speakers, motivation from peers, academic preparation, and guidance about applying to colleges from counselors. These findings help to answer the second research question in this study about the influence of camp on participants' higher education/career trajectory. The data suggests that RSMC had a crucial impact on the participants' higher education/career trajectory and the decisions they made regarding applying to some of the top-ranked institutions of higher learning by increasing their SC. For three of the participants camp also impacted their aspirations and decisions about

choosing a major in college. We may note from the perspective of the participants how access to and use of embedded resources in RSMC enhanced their chances of attaining better statuses with respect to higher education and career related decisions.

While two of the participants, Anahi and Hima, successfully graduated with STEM degrees from University A and University B respectively, Mira and Samara however felt that they were marginalized from their initially chosen STEM majors at University C. Mira and Samara both ended up graduating from University C with a non-STEM undergraduate degree. Mira also completed a graduate degree at University C in education. Samara has recently made a come back to her original passion of computer science. She is currently pursuing her graduate studies in tech literacy and theology.

#### **RSMC characteristics/practices valued by the participants**

In each of the case reports I described the aspects or practices of RSMC that were valued by the participants in two points of time – in the past when they were campers or counselors during their high school/college years and in the present (in hindsight) as they look back on their camp experience as mature adults. We also noted in the case of Samara some of improvements that were suggested for camp to make this experience even more valuable for future campers. In this section I report on some of the common practices/components valued by all four participants in the past and in the present that led to the impact on their respective MLI and SC. The findings here help to answer research question 3 in terms of practices and components that were commonly valued by all four participants as well as note any differences. The participants reported these practices either in the past evaluation of the camp or at present when they were asked to describe the practices or components that they value in hindsight from their camp experience. We

may note that some of the camp practices that the participants directly state that they value turn out to be the same practices of the RSMC learning setting that I identified from the data influencing their MLI and SC. However, it is important to note the distinction between what I identified influencing the aforementioned constructs based on my analysis of the data and what the participants directly say that they value. Identifying the characteristics/practices of RSMC that the participants report as important to them or the big take-away from the camp experience also helps establishing an equity framework for informal programs in particular, and learning environments in general. In the next chapter, I will present this framework based on the findings of the research questions in this study.

Common practices or components that were valued by all four participants in the past when the participants were campers or counselors at RSMC include – help and mentoring received from the counselors, the experience of being a counselor themselves, teaching practices at camp, study groups, and the camp curriculum. Social aspects such as weekend trips and weekly colloquiums were valued by three of the participants. The following comments from the past camp evaluations and essays of the participants illustrate that these practices were highly valued:

Table 16

*Common practices valued in the past*

RSMC Practices/Components	Anahi quotes	Hima quotes	Mira quotes	Samara quotes
Camp Counselors (help received from her counselors as campers)	<i>"[Mira] is the best counselor I could have had. She really helped our group out and brought us snacks"</i>	<i>"[Kenny] [counselor] went over the ambiguous parts of the number theory class. That was helpful"</i>	<i>"[Anna] was an awesome counselor... She knew to make you think deeply about the problems and always had a word of praise..."</i>	<i>"I understand everything [Cory] talks about...He comes during our study group and helps"</i>
Camp Counselors (being a counselor mentoring campers)	<i>"It seems like not too long ago was the 1<sup>st</sup> day the campers arrived... my group continues to amaze me...man am I going to miss having them around &amp; checking up on them"</i>	<i>"It's been a pleasure coming back as a counselor and seeing a group of first years becoming better thinkers and better persons"</i>	<i>"I love working at [RSMC] because it puts me in contact with a wide variety of talented youth who in six weeks acquire a new way of looking not only at Math, but also themselves."</i>	<i>"I enjoy making and nurturing the relationships"</i>  <i>"A comradery, foundation of acceptance, and trust ...allows me to best relate to campers"</i>
Teaching practices	<i>"I also like the way he [Tony] doesn't tell us the answers, he only insinuates it."</i>	<i>"[Edmund] is a wonderful teacher – through and clear in his explanations"</i>	<i>"The best thing I liked...was that you were allowed to work at your own pace"</i>	<i>"[Edmund] was available and ready to answer questions"</i> <i>"everybody was encouraged to research things, for opinion"</i>
Study groups	<i>"I liked the group I had...I had a lot of fun with this group...our group got a lot of work done when we didn't fool around..."</i>	<i>"I do appreciate the wide-ranged thinking modes in my group."</i>	<i>"...my group was great. Whenever I got stuck on a problem, there was always someone to ask for help"</i>	<i>"surrounded by so many intelligent people, I get to meet all kinds of ... perspectives. I feel ... I am able to stretch my capabilities"</i>
Camp curriculum	<i>"I enjoyed Research Topics... I got to learn different topics about math more thoroughly."</i>	<i>"I truly enjoy learning Combinatorics ..."</i>	<i>"I enjoyed the classes...Combinatorics I found extremely interesting."</i>	<i>"I started liking Mathematica as I liked learning an introduction to Visual Basic"</i>

Table 16 Continued

Social aspects such as weekend trips	<i>“The weekend trips are great...allows students to bond with other people”</i>	<i>“talking about the upcoming events for the weekend – a rafting trip! I’m looking forward to all that...”</i>	<i>“the service project...picking up rocks to build a dam was practical...the overall experience was enthusing and inspiring”</i>
Colloquia	<i>“[Sarah Cole] showed us really cool chips from computers and gave us examples of how to program”</i>	<i>“[Delores] covered some very interesting topics”</i>	<i>“[Delores]...her talk helped me understand the mathematics behind [internet] searches and helped me to better my own searching”</i>

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Mira was the only participant whose past data suggests that she also valued a sense of a community that she experienced at RSMC. Analyzing Mira’s past documents, I found five occurrences of quotes that support the finding that Mira saw RSMC as a community that values diversity, creates an environment of acceptance and mutual respect, and provides opportunities to grow as a person. Below I include two of these quotes:

“The people that attend this camp come from a variety of backgrounds, having different socio-economic situations as well as ethnic backgrounds and beliefs, yet anybody, having only the desire to try, has the ability to fit in and be accepted for who they are”

“I am able to take with me something new and valuable that I’ve learned here...and apply it to my normal life outside of math camp, helping me to become that much of a better person”

How do the camp practices valued by the participants in the past compare to ones valued at present in hindsight? Assessing an experience years later as mature adults, the participants describe their big take-away from camp. One participant also provides suggestions for improvement. Common practices or components that were valued by at least three participants at present include – study groups, mentorship received from the camp director, Mark, teaching practices at camp, a sense of community (experienced slightly different from each other), the help and mentoring received from the counselors, social aspects (e.g. weekend trips), exposure to life on a college campus, and the camp curriculum. The following comments from the recent interviews, survey, and correspondence of the participants illustrate that these practices were highly valued:

Table 17

*Common practices valued in the present (in hindsight)*

RSMC Practices/Components	Participants' quotes
A sense of community	<i>"Collaborative community, one focused on learning from each other and growing together...It forces everyone to work together in groups and sets up weekend events that require partnership and teamwork. It also gives students the liberty to do what they like and think is correct instead of constantly parenting and correcting them." – Anahi</i>
Mentorship received from Mark	<i>"that conversation, um, really jostled my entire understanding of my capabilities and my capacity." - Samara</i>  <i>"It's not often in a person's lifetime that one comes across a teacher, a mentor, and an advocate who has been so influential..." – Hima</i>
Teaching practices	<i>"...to let students think and learn for themselves, whichever their approach...providing different ways to learn and letting the students seek the help they desire from the method they prefer." - Anahi</i>  <i>"I just love the fact that all of the faculties emphasized the enjoy the journey of learning part which is more important than the end goal" – Hima</i>  <i>"I got a lot of support. I remember [Mark] would grade some of my problems sets. He would draw little bunnies...[for] Turtles right", and suddenly I felt good" - Mira</i>

Table 17 Continued

Study groups	<p><i>“The group in the evening I think <b>was huge</b> for me. It taught me about how <b>learning could be student directed</b>...It also taught me about how there are more resources than just the teacher, and what it is to mean to take advantage of those resources” - Mira</i></p> <p><i>“Group study sessions – it’s the one area where through constant interaction I learned as much from others as they did from myself.” – Anahi</i></p>
Camp Counselors (help received from her counselors as campers)	<p><i>“I had a really good counselor who was coaching me through the steps,...that made me feel at ease.” - Anahi</i></p> <p><i>“a camp counselor embodies a lot what your experience is going to be like. So, their personality, their attitude, the way that they, um, approach their position can really make a difference...” – Samara</i></p>
Camp curriculum	<p><i>“...introducing me to concepts like mathematica (coding), graph theory (and its applications), analysis (calculus levels above my high school experience), and number theory (the class that proves what I took for granted).” -Anahi</i></p> <p><i>“It [camp] certainly completely blew the lid off of my, uh, <b>understanding of what math was</b>...So, I feel like, um, that was such a <b>huge takeaway</b>, just to see so much more of the field” – Samara</i></p>
On campus residential aspect of RSMC	<p><i>“I definitely self-reflected on the college dorms, I learned the type of person I am, valued help and support” - Anahi</i></p> <p><i>“...what you expect in the future, like the structure learning environment in college... that aspect was pretty good” – Hima</i></p>
Social aspects at RSMC (weekend trips, socializing with peers)	<p><i>“<b>Loved weekend trips</b> – most were a 1st for me...It just, uh, you <b>learn other things</b> from other people that you <b>see them in a different light</b> and a different setting... I really appreciated seeing that...it really helped kind of <b>bond</b> me <b>with additional campers</b> and I think it was one of the reasons <b>why I continued coming back to camp</b>” – Anahi</i></p>

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Hima was the only participant whose recent correspondence suggests that she also values the practice of journaling in hindsight as a form of mentorship. While Samara was the only participant who in hindsight also values the component of weekly colloquiums as a practice which allows campers to connect mathematics “to the outside world” and offers role models for campers to follow. Samara was also the only person who suggested

improvements for camp to make this experience even more valuable for future campers. Her suggestions were – (i) increasing the “number of certain minorities and women” when recruiting campers, (ii) conveying the equity oriented vision of the camp more effectively, and (iii) including more talks in the colloquiums about “the history of women or the history of people of color” in math or other STEM areas.

As noted above each girl experienced a slightly different sense of community at RSMC. The *kind of sense* of a community that was experienced by each participant is described below:

Anahi – RSMC is a collaborative community that encourages learning from each other, camaraderie, and team spirit. A community that provides help and support, encourages independent thinking and respects individual choices.

Hima – RSMC provides a safe, sheltered, and friendly environment of acceptance and to be yourself. Camp encourages a non-competitive environment of like-minded peers to enjoy the process of learning math. RSMC community encourages independent thinking to explore different interests and values individual choices. Camp offers more than just an educational experience; it offers a transformative and life-changing experience for young campers.

Mira – RSMC provides a sense of a collaborative environment where the entire community (peers, counselors, teachers) comes together to provide help and support. RSMC community upholds the belief that everyone has something unique to contribute and can succeed through hard work irrespective of their background. Camp values diversity, offers an environment of acceptance and mutual respect, and provides role

models. Camp is more than just an academic experience; it equips students with life skills and provides opportunities to grow as a person.

Samara – The RSMC community is a source of inspiration. In camp you are surrounded by examples of ambitious and successful people who are also down to earth and often become your role models. The community at RSMC is friendly and welcoming where teachers, counselors, and staff socialize with the campers and make them feel at home. The point of camp is not just preparing campers to pass some test, it transforms you into becoming better human beings wanting to pay it forward.

### **Summary**

This chapter presented the findings of the study through four embedded-case reports as well as described the findings of the four participants analyzed as a group. Each case report and the cross-case analysis was divided into three sections: MLI co-construction and shifts, Higher Education Trajectory upon leaving RSMC and RSMC characteristics/practices valued by the participant that corresponded to the three research questions for this study. In the next chapter, I will present - a discussion of these findings situated within the larger body of the literature, implications from these findings and lessons learned from each case report, an equity framework based on the findings applicable for any learning setting, and recommendations for future research.

## **V. DISCUSSION AND CONCLUSION**

This is a qualitative single-site embedded case study where RSMC (the learning environment) forms the main unit of analysis and four former women participants from diverse backgrounds constitute the embedded units of analysis. The three research questions that guided this study are:

1. How do the women participants (1990 – 2008, from low SES and/or minority background) of an informal, university affiliated, summer math camp –RSMC envision its influence on their mathematics learning identity?
  - a. According to the participants, what was the nature of their mathematics learning identity (1<sup>st</sup> P) at the time they started the program?
  - b. What views did these participants hold in the past (as recorded in their past documents such as journals) and what views do these participants hold at present (as narrated in their recent interviews, correspondence, survey) about the influence of RSMC (i.e. its particular affordances) on development of their mathematics learning identity?
2. How do the women participants (1990 – 2008, from low SES and/or minority background) of RSMC envision its influence on their higher education and/or career trajectory in STEM areas?
3. Which particular characteristics/practices of the RSMC program did these participants come to value, if any, that led to the above impact?

In the previous chapter I described the findings of this study through four embedded-case reports. Each report was divided into three sections: *MLI co-construction and shifts*, *Higher Education Trajectory upon leaving RSMC and RSMC characteristics/practices valued by the participant*. The three sections in each embedded-case corresponded to the three research questions. There were additional findings that came to light about the college experiences of two of the four participants, which were included in the case reports of these participants under the section – *So, what happened in college?* A cross-case analysis of the key findings among all four participants was also presented in the previous chapter. As described in Chapter II, the ecological and situative perspective informs my analytic lens for this study. Using this lens and the identity-resources framework (Nasir & Cooks, 2009) I analyzed my data and answered the research questions for the study. Interviews with the participants constituted one of my primary data sources for each of my research questions. The documents that constituted supporting data sources for this study include participant journals, camp evaluations, correspondence with RSMC faculty, a recent survey, and demographic data about student body at RSMC from 1990 – 2008.

In this chapter I will include: (i) a discussion of the key findings with respect to the three research questions as well as the findings that relate to the college experiences of two of the participants and situate this discussion within the context of the existing literature; (ii) implications for math educators to use in various settings, and policy makers for supporting and funding efforts of university affiliated math camps (iii) a framework for establishing an equity based education model (aiding in the construction of positive, holistic, and broadened learning identities) that applies to informal math

programs or can be extended to other learning settings, and (iv) recommendations for future research.

### **Research question 1: Trajectories of identities**

#### **Pre-MLI co-construction**

All four participants subscribed to a narrow and limited view of mathematics and its learning prior to RSMC experience. All four participants described mathematics as either a “bunch of numbers or equations” with “no practical application”, “series of formulas”, “problems...that always had one exact answer”, a non-creative field, or just “algebra and geometry.” Each participant thought that doing or learning mathematics meant memorizing procedures and rules given by the teacher to get a high score on the test. All four associated speed and getting to the “right answer quickly” with doing math. While Anahi, Hima, and Mira described math as a solitary activity, Samara described it as a process of “performing functions like a human calculator.” For Anahi and Hima being successful in Math also meant competing against their peers. All four saw mathematics as rote and teacher-driven.

What kind of a *way of knowing* do these findings suggest for Anahi, Hima, Mira, and Samara before RSMC in terms of the personal epistemologies described by Becker (1995)? We can see that before coming to RSMC they primarily fit the category of a received knower. Recall that Becker (1995) describes received knowing as a category in which the individual considers her knowledge to be given to her from an authority. She memorizes then mimics/repeats the words of the authority without questioning or understanding the knowledge of the authority. The findings also show that all four participants were positioned into a *passive* role as a learner by the practices of their

learning environments. They were “receivers of predetermined knowledge that appeared unavailable for discussion or negotiation” (Boaler & Greeno, 2000). These students engaged in “ritualistic acts of knowledge reproduction” rather than questioning procedures, figuring out why, or looking for different ways to approach a problem (Boaler & Greeno, 2000). All four participants considered themselves as excellent students of mathematics prior to RSMC. This perception was based on their grades and the discourses among students or teachers and students about being “good” at math that were prevalent at their schools. These discourses equated competence with memorization of procedures, speed, and high scores on tests. Such discourse spaces in which students or teachers and students participate often originate through “institutionally supported beliefs about ability and ownership of knowledge” (Solomon, 2009). This finding suggests that Anahi, Hima, Mira, and Samara had developed behaviors to succeed in the “ecologies of didactic teaching” in their respective learning communities (Boaler & Greeno, 2000). These students had become “excellent” in memorizing procedures and maintaining top rank in class. The findings also relate to Solomon’s (2009) work about learning identities in which she argues that “a positive learner identity” is “not necessarily an identity of potential engagement” in the “wider world of mathematics.” Sometimes, “students who describe identities of heavy alignment” and consider themselves successful in math “can appear unworried by their lack of participation in mathematics” (Solomon, 2009). However, “it is possible to make sense of this puzzle” by considering how these students interact with the discourse space and “institutionally supported beliefs about ability and ownership of knowledge” (Solomon, 2009). What discourses do the students draw upon? What makes for “success” in the communities of practice of the students? These are the

questions that we should consider when making sense of learning identities (Solomon, 2009). For Anahi, Hima, Mira, and Samara to be successful in their school math classrooms, they needed to “assume the role of a received knower and develop identities that were compatible with a procedure-driven figured world” (Boaler & Greeno, 2000). These environments position students into accepting a particular form of knowing and authoring “identities that give human agency a minimal role” (Boaler & Greeno, 2000).

Before coming to RSMC each of the four participants subscribed to some type of racial, socio-economic status, national origin, or gender ‘storyline’ or narrative prevalent in society (Nasir et al., 2012). Anahi, Mira, and Samara saw their race, gender, and class as obstacles to learning. They considered themselves good at math despite the race, ethnicity, gender and class constraints of their situation. They thought of themselves as “an exception” or “special” because they bought into the stereotype that Hispanics or Blacks from underprivileged backgrounds aren’t usually good at math. For example, Samara makes the following comment in her interview “they[family] thought that I was, you know, acting white when I used a big word. So, it was still, um, intelligence or smartness was coded as being white. Um, and it wasn't an identity, that I could hold as a black -- a young black woman.” Therefore, for Anahi, Mira, and Samara to be considered academically good by their high school teachers meant that they must an exception to the norm. On the other hand Hima bought into the stereotype that she is naturally good at math since she was from China or because she was Asian. The way she was treated in her middle school and high school by her peers and teachers served to reinforce this stereotype. Although this may seem like a positive and affirming message about Hima’s race or national origin, it did however negatively impact Hima’s social and emotional

development. She was only valued for her math skills in school. Her peers did not bother to see her as a whole person with other qualities. It was hard for her to find acceptance and make friends. Following are some of the comments that Hima made in her interviews and correspondence:

“everybody gets kind of falling into a category... Math So I think that's where I kind of ... Falling into that category...”

“I had difficulty adjusting to changes and finding acceptance, especially when I was mostly known for my math skills.”

“sometimes it's like being a nerd in high school ... It's just kind of, like, a bad thing ...”

These findings relate to the work of Nasir et al. (2012) in which they argue that “racial ‘storylines’ or narratives are prevalent in our society and have powerful implications for learners, particularly for youth from marginalized communities” and “these racial storylines are a critical aspect of life in schools, which serve the purpose of racially and academically socializing students.”

### **Post-MLI co-construction: shifts during RSMC**

All four participants took a came to question to their positive pre-MLI during the first year at camp as their conception of mathematics and learning was being shaken by the practices of RSMC which valued thinking, questioning, collaborating, and deep understanding over speed, memorizing, grades, and compliance. All four participants mentioned that they went from having a very narrow view of mathematics (*just algebra & geometry; a field that has no practical application, a non-creative field, a bunch of numbers and equations*) and what it means to be successful in it (*speed, working alone*

and competing against peers; memorizing teacher's procedures and formulas; getting good grades) to a much broader and realistic view of what constitutes the realm of mathematics (*a vast discipline; a field with many applications in different areas; a creative discipline*) and what does it mean to be successful in it (*learning from peers and through discussion with others, exploring diverse perspectives; understanding why a method works; taking risks; persisting; developing internal understanding*). What type of a way of knowing do these findings suggest for Anahi, Hima, Mira, and Samara during and post RSMC in terms of the personal epistemologies described by Becker (1995)? We can see that as a result of attending RSMC, their epistemologies shifted from that of a received knower to a constructed knower. (*Individual considers her knowledge as primarily being constructed in interaction with other people. Learner appreciates the complexity of knowledge through a process that depends on understanding others' perspectives, reasoning, and experiences and incorporates this understanding into the individual's knowing and understanding. She then uses rules of discourse and deductive logic to construct her knowledge of the concept.*) These findings also echo some of the results presented in Boaler and Greeno's (2000) work when describing ecologies of discussion-based teaching. The same students who presented their figured worlds as "structured, individualized, and ritualized" prior to RSMC, came to view mathematics and learning as "relational, communicative, and connected" (Boaler & Greeno, 2000). The RSMC community of practice had a significant impact on the participants' positioning as learners. We can see that the same group of individuals went from being positioned into a *passive* role when it came to learning math in their middle school and high school math classrooms to taking an *active* role "considering and interpreting the

meaning of the procedures they encountered” at camp (Boaler & Greeno, 2000, Solomon, 2009). At RSMC Anahi, Hima, Mira, and Samara engaged in negotiating and interpreting the meaning of mathematics that lead to their more broadened and progressive views of mathematics as a discipline and saw that their role as learners went far beyond just memorization (Boaler & Greeno, 2000, Solomon, 2009).

As illustrated in chapter 4, by making available material, relational, and ideational identity resources (Nasir & Cooks, 2009) throughout their time in camp, RSMC helps create an inbound STEM identity trajectory for Anahi, Hima, Mira, and Samara. Over the course of their affiliation with RSMC, all four participants became more connected to the practice of mathematics and developed a broader and more holistic learning identity in the context of math in particular and STEM in general. RSMC was able to shift the identity trajectories for the participants by providing support structures in place for the campers. Anahi, Hima, Mira, and Samara were all supported by their camp counselors, teachers, peers, and personally mentored by the camp director during the challenging times at camp when doing or learning mathematics seemed overwhelming and a completely different process than the one they were used to. The fact that the participants were able to shift their identity trajectories by experiencing learning in a different community of practice suggests that as “the values, assumptions and rules of engagement and communication of a practice” in a community or learning environment change, then our participation and interaction with the practices of this new environment will impact our understanding of the practice itself, its learning, and ourselves as learners of the practice (Solomon, 2009; Greeno & Gresalfi, 2008). The finding also affirms the fluid nature of identities that can be viewed as a function of properties of our actions overtime

i.e. trajectories resulting from past experiences that shape our future in a given figured world (Solomon, 2009; Nasir & Cooks, 2009; Gresalfi & Greeno, 2008; Sfard & Prusak, 2005; Boaler & Greeno, 2000).

Just as the students in ecologies of discussion-based teaching in Boaler and Greeno's (2000) study noted the importance of relationships between people when describing their figured worlds in the context of learning math, so did the four participants in this study. Anahi, Mira, and Samara recalled the crucial role their first and second year counselors played in their learning. All four girls also valued the role they played to support and mentor a new cohort of campers by returning to camp as counselors themselves. This illustrates how RSMC makes relational resources (Nasir & Cooks, 2009) available to campers through one of its structural components – counselors. By assigning counselors to each group, RSMC provides an essential support structure to new and returning campers.

Similarly, the mentoring that Hima received from the camp director was instrumental in the development of her MLI trajectory. Hima recalled the conversations that the director would have with campers in which he would remind everyone that the point of learning was “not to see who came up with the solution the fastest” but rather in “persevering through difficult tasks” together and enjoying “the beauty inherent in the thinking process itself.” Hima also valued the practice of journaling and considered it an important “line of communication” through which she could “convey [her] frustration[s] without the awkwardness of direct speech.” She appreciated the time the camp director took to read and comment in her journals. She recalled that “It was nice knowing that at the end of the day, somebody cared about what you had to say about the world around

you.” This illustrates how valuable the practice of journaling was to Hima. Journaling serves as a great relational resource (Nasir & Cooks, 2009) through which RSMC students can build a strong and meaningful relationship with their mentor. The practice also affords the camp director an opportunity to nurture the campers’ MLI. Similarly, Mira and Samara both recalled the conversations the director had with them and he how did not give up on them when they were struggling. Both girls felt that the director was invested in their learning and took the time to check up on their progress.

All four participants also noted the important role that the teachers played in supporting their learning such as visiting their study groups in the evening to offer help, having high expectations from them, pushing them to venture into “uncharted territories and discover new ideas,” instilling confidence in them to persevere, and socializing with them in non-classroom settings such as lunch, picnics, weekend trips, and going out for ice-cream. Furthermore, conversations that the camp director had with each of the participants were especially important and went a long way to reducing stress in a challenging and new learning environment. These conversations and the uplifting comments made in their journals helped each girl find a mentor who believed in them.

Each participant appreciated the practice of study groups and recalled bonding with their group mates through the process of working on challenging math problems together. This practice helped each student learn how to get along and work with a diverse group of peers. By working together, the campers came to appreciate different perspectives and value diversity of skills among their group mates. The practice also taught them that how “learning can be student directed” and occur through discourse and

collaboration. This way of learning was more productive and enjoyable than working in isolation and competing against peers.

The above illustrates how RSMC makes material, relational, and ideational resources (Nasir & Cooks, 2009) available to campers through its structural components and practices – mentorship and guidance from the counselors, teaching practices, mentorship from the camp director, the practice of journaling, and study groups. By implementing teaching practices that give students agency and provide the necessary support when needed, encouraging counselors to take on the role of a mentor and a teacher, providing personal mentorship from the camp director, and by having the camp director read and respond to the campers' journal entries, RSMC provides an essential support structure to new and returning campers. Socializing with the campers in non-classroom settings also plays an important role in building positive relationships between teachers and students. Furthermore, the mandatory study groups, which are a structural/organizational component of RSMC, serve as a material, relational, and ideational identity resource (Nasir & Cooks, 2009). They are a material resource as a structural component, a relational resource because they provide an opportunity to build relationships with peers, and an ideational resource because the expectation is to collaborate with your peers, which sets the tone of what is valued at camp.

The findings above again echo some of what Boaler and Greeno (2000) found in their study of the discussion-based classrooms. Stories of the participants in this study suggest that the relationships that they formed at camp were central to their learning “rather than a causal by-product of a change in pedagogy” (McLaughlin & Talbert, 1999 as cited in Boaler & Greeno, 2000). The importance of relationships and what it means to

make an identity available in a learning context are also discussed in the work of Nasir and Cook (2009). The interaction between the participants and their teachers, counselors, and peers, “fostered social relationships” that helped each student persevere through challenging moments (Nasir & Cooks, 2009). For all four participants RSMC provided a similar yet slightly different sense of a community, some of whose elements included the following:

- a safe and collaborative environment of acceptance;
- an environment that values diversity and upholds the belief that everyone irrespective of background has something unique to contribute;
- a non-competitive, stress free place to enjoy math through self-paced learning;
- a place where you are not afraid to make mistakes, where you are taught how to deal with failure and see it as an opportunity to learn something new;
- a place where individual thinking and choices are valued and giving back to the community by helping others is encouraged;

Each participant mentioned that attending RSMC as campers and returning as counselors helped them realize that they can be successful in math or any other field that they desired. Math camp was not just about learning advanced math to pass some test but rather it helped them become better human beings wanting to change the world. This is a powerful finding and illustrates that the role a learning community can play in students’ lives can be formative and life changing. Communities like RSMC don’t just produce a workforce for STEM fields trying to fill in an industrial need in society, but rather inspire

students to become visionaries wanting to make a difference. The vision of RSMC as enacted by teachers, counselors, and staff serves as an ideational identity resource (Nasir & Cooks, 2009) by communicating to campers what is valued in this community of practice. This shared vision and practices can then help campers develop more holistic and broadened learning identities and offer an opportunity to go through a transformative experience during their formative years. Just as the ideational resources were crucial in developing practice-linked identities in the work of Nasir and Cooks (2009), they are fundamental in shifting identity trajectories of the participants in this study. The above finding about the sense of community the participants experienced at RSMC, illustrates impact of a shared vision that is based on equity. The power of what is valued in a community and how the participants are made to feel like an integral part of it is central to identity formation (Nasir & Cooks, 2009).

Recall that before coming to RSMC each of the four participants subscribed to some type of racial, socio-economic status, national origin, or gender ‘storyline’ or narrative prevalent in society (Nasir et al., 2012). However, for three of the participants these stereotypical views were disrupted after the RSMC experience. Upon attending RSMC, we see that Anahi found in her counselor Mira a role model of a Hispanic woman who was successful in a diverse setting. Unlike her earlier perception where she thought being Hispanic from a low-income family was a constraint to being successful and had something to do with one’s *ability* to learn and succeed, having found a counterexample in her counselor Mira, Anahi no longer subscribed that view. She came to believe that Hispanic women from low-income families can be successful in diverse settings and being such a woman herself, she could be successful too. This suggests that her finding a

successful role model in a person of same gender, class, and ethnic background was crucial to her confronting the ‘storyline’ she previously believed.

Mira credited the sense of community that she experienced at RSMC in helping her confront her previously held views about *who is* capable. She made the following comments in her past documents and a recent interview:

“That you can offer something regardless of the background that you have, and then that influences who you become.”

“Like if you have the right resources, and the right support you're going to be fine.”

“the fact that I feel so positively about it[camp], and I am female, and I am Latino. I think it speaks to the impact that the camp can have...It was I [Mark, the director] want[s] to figure out what it means to serve a different population, than the one that traditionally succeeds in math... I mean go [Mark]!”

Mira saw herself as part of a community where diversity was valued, people were accepted for who they were, and a belief that everyone irrespective of their background has something unique to offer and can learn math through hard work was upheld. By seeing herself and others succeed in a diverse environment through hard work and support of the people, Mira came to believe that a person’s race, ethnicity, gender, or class has nothing to do with their ability to learn. Anyone irrespective of their background can be successful through hard work and by being part of a community that supports and values diversity. For example, Mira made the following comments in her past camp evaluation and a recent interview:

“The people attend this camp come from a variety of backgrounds, having different socio-economic situations as well as ethnic backgrounds and beliefs, yet anybody, having only the desire to try, has the ability to fit in and be accepted for who they are”

“being able to succeed still there regardless of my background”

“It wasn't like I thought I had some innate ability that other students, that my peers didn't have... I just thought I just work[ed] harder”

For Hima it was the diverse group of peers that she met at RSMC, who helped her confront her stereotypical views. She made the following comments in her past journals and in a recent interview:

“after getting to know so many super intelligent and talented people at camp, I realize in so many ways they are just like me”

“... You open your eyes to, like, what people really know, ... you do [get] exposed to a wide range of smart people. I think that's a really good thing. Like, you know, for people, when they grow up”

The above comments suggest that by being in RSMC environment where she met a diverse group of peers who were just as knowledgeable as herself helped her break through a previously held notion about being naturally good at math just because she was from China. She came to the conclusion that the properties of race, ethnicity, or national origin had nothing to do with one's abilities to understand and learn math.

For Samara the RSMC experience helped her to connect with a diverse group of people and she appreciated learning from different perspectives as well as the support she received from her teachers and counselors. She learned that she could succeed at math or

any other field through hard work and perseverance. However, this experience did not end up confronting her original perception that she had prior to coming to RSMC that she was an exception among her community as a result of being good at math. For example, she made the following comment in her recent interview “The average person didn't look like me... I was like, Oh, I must be rare. I must be special.”

So, given the same learning environment, community vision, and support structure, why is it that Anahi, Hima, and Mira were able to disrupt their racial ‘storylines’ but Samara was not? To make sense of this puzzle I turned to the demographic data during the years these girls were enrolled in the camp. The following table and pie charts describe the demographics of the student body make up of RSMC over the years 1990 – 2008.

Table 18  
*Number of students in different ethnic groups over the years 1990 – 2008*

Year	Caucasian	African/Black	Hispanic/Latin		Asian	Other	Total
			o				
1990	7	5	3		0	1	16
1991	10	6	2		0	0	18
1992	16	3	11		5	4	39
1993	11	4	13		9	3	40
1994	15	5	17		11	3	51
1995	17	7	16		13	0	53
1996	14	3	17		12	1	47
1997	20	6	13		9	1	49
1998	25	5	9		9	0	48
1999	22	5	7		14	0	48
2000	22	3	9		18	0	52
2001	17	7	14		15	0	53
2002	13	9	22		14	0	58
2003	14	4	10		20	2	50
2004	18	1	6		27	0	52
2005	11	4	12		23	1	51
2006	11	1	8		26	6	52
2007	13	7	10		23	3	56
2008	10	7	10		26	4	57

Mira attended camp in the years 1997 and 1998. During 1997 there were 13 Hispanic students enrolled in the camp and the following year there were 9. There were 25 girls and 24 boys in 1997 while 21 girls and 27 boys in 1998. Although not a clear majority, there were still a significant number of campers who looked just like her and were able to succeed in a diverse learning setting. Anahi attended as a camper in the years 2001 and 2002, which were both good years in terms of diversity. Mira was also at camp as counselor mentoring new campers during these years. In 2001 there were 14 Hispanic, 7 Black, 15 Asian, and 17 Caucasian students with 27 of those girls and 26 boys. In 2002 there were 22 Hispanic, 9 Black, 14 Asian, and 13 Caucasian students with 28 girls and 30 boys. Seeing a great many examples of Hispanics and female students succeed in a truly diverse environment, both Anahi and Mira were able to confront their deficit views about their race and gender. Hima attended camp during 1998, 1999, and 2000 as a camper and she returned to camp as a counselor in the years 2001 and 2002. During these years Hima met a great number of non-Asian students who were just as knowledgeable and prepared in math as her. For example, in 1998 (the year Hima started camp) there were 9 Asian, 9 Hispanic, 5 Black, and 25 Caucasian students. This gave Hima examples of 39 non-Asian and 14 non-Asian as well as non-White students who were brilliant. During the years of 2001 and 2002 when Hima was a counselor, there was a huge contingency of Hispanic and Black campers – *21 in 2001 and 31 in 2002*. This helped Hima confront her fixed-ability views with respect to national origin or race. On the other hand, Samara attended camp during the years 2003 and 2004 and came back as a counselor in 2005. In 2003 there were 4 Black, 10 Hispanic, 20 Asian, and 14

Caucasian students of which 22 were girls and 28 were boys. In 2004 there were 1 Black, 6 Hispanic, 27 Asian, 18 Caucasian students of which 20 were girls and 32 were boys.

Samara's made the following comment in one of her interviews:

“it was suddenly galvanized that I was a black person who loved math, I was a [black] woman who loved math, and that was galvanized, because I was put up alongside such an overwhelming majority of people who liked Math Camp looked like, who Math Camp was. The average person didn't look like me... I was like, Oh, I must be rare. I must be special.”

The above comment when seen in the context of the student demographic data during the time Samara was at camp, makes sense as to why Samara was unable to confront her previously held views about being an exception within the Black community. However, Samara did acknowledge the invaluable experience she had at camp where the teachers and counselors were invested in her learning and cared about her future. She considers RSMC to be a life-changing experience for her and credits camp for helping her find her true passion for computers and math.

The following comments from Mira when looked in context of the data also makes sense as to how she was able to confront her racial and gender storylines about the Hispanic community and women:

“the fact that I feel so positively about it[camp], and I am female, and I am Latino. I think it speaks to the impact that the camp can have. Specifically, because it's not just ... What do you call it. It wasn't just lip service. It was I [Mark] want to figure out what it means to serve a different population, than the one that traditionally succeeds in math...”

“he [Mark] also started expanding socio-economically, and racially. I don't know what the ratios is now, but my last year as the head counselor was the first time that there was a significant contingency of kids who were Black, and Latino. Who came from backgrounds like my own.”

Mira saw the vision of RSMC that everyone irrespective of their background has something unique to offer and can learn math through hard work transpire within a truly diverse body of campers where she saw not only herself succeed but many other students who looked just like her also succeed in a diverse setting. Similar experiences in the case of Anahi and Hima (seeing other minorities do well) helped them to construct broadened perspectives on learning and success. The above findings resonate with the work of Nasir et al. (2012) about “the potential of alternative spaces, which can serve to counter dominant narratives about *who is* capable of learning and how learning takes place, and open new spaces for identity and learning”. The findings from the cases of Mira, Anahi, Hima, and Samara are a testimony to the point Nasir and associates (2012) make in their article titled ‘Racial Storylines and Implications for Learning’. The importance of diversity in learning settings is essential in confronting some of the dominant narratives.

By striving to maintain a diverse student body and succeeding in maintaining it during the years Anahi, Mira, and Hima were campers and counselors, RSMC was able to help these girls counter their deficit views and construct powerful understanding of themselves. Even though Samara attended camp during the years when there weren't as many black campers, her description of RSMC as an invaluable and life-changing experience where teachers and counselors were invested in her learning and cared about her future and where she found her true passion of computers and math, is a testimony to

other characteristics and practices that are also essential in creating an equity based learning setting. Communities like RSMC that believe in their students, believe that everyone has something valuable to contribute irrespective of their background, value diversity and strive hard to increase it in their setting, take an active role in providing *every kind* of support to their students, are invested in their students' future, encourage independent thinking, and respect individual choices, tend to impact not just a student's learning but their holistic sense of self and world view.

### **Research question 2: Higher Education Trajectory upon leaving RSMC**

All four participants reported varying degrees of limited social capital prior to coming to RSMC such as financial constraints, level of parental education, lack of role models, discouraging family environment, unmotivated peer, difficulty in finding acceptance, and lack of guidance with respect to higher education and career matters. As a result, the participants reported in varying degrees that they were ready to make a set of modest decisions concerning their future education/career plans due to their limited SC. This finding resonates with the results of some of the other studies (e.g. Eagan et al., 2013; Berzin, 2010; Bok, 2010; Lin, 1999; Coleman, 1988; Bourdieu, 1986) that identify SC as an important factor impacting people's educational and career aspirations and trajectories. For example, Berzin (2010) studied educational aspirations among low-income youth. The author examined the influence of variables derived from status attainment theory, blocked opportunities, and social support theory on educational aspirations of 11, 154 low-income youths. Some of the variables that Berzin (2010) found in her study associated with post-high school aspirations among low SES students included gender, race, level of parental education, parental occupation, parental support,

educational experience and relationship with school environment, peer support, engagement and academic performance in school. Even though in my study the limited SC did not impact the participants' aspirations, it certainly impacted the set of modest decisions that the girls were planning on taking regarding their higher education and career plans. For example, Mira and Samara's families did not support the idea of going to a big university. Samara's family wanted her to get a job after high school while Mira's family supported the idea of her attending a local community college on account of her being a girl. Although, Anahi wanted to be an engineer, her plan to realize this dream was to attend a local community college because in her circle of family and friends everyone stayed close to home. On the other hand Hima reported that her parents had already planned her future in which she was to pursue higher education in computer science or math. They did not respect her choices and she received no encouragement from her family to figure out her own interests with regards to a career path. However, upon attending RSMC, each participant's SC was affected through the interaction between the participant and the components of the RSMC environment such as peers, counselors, and teachers. According to the participants, RSMC had a crucial impact on their higher education/career trajectory and the decisions they made regarding applying to some of the well-respected institutions of higher learning. Following are some of the comments that participants made during their recent interviews and correspondence:

“...my life trajectory was augmented and changed forever because of that conversation with [Mark]... that conversation, um, really jostled my entire understanding of my capabilities and my capacity” – Samara

“I would say that the math camp definitely made, made those schools [MIT, Harvard, other top-ranked schools] even a possibility (laughing) on my radar...it definitely led to a lot of opportunities I would never have thought about... You know, like I couldn't have pursued medicine” – Hima

“The counselor in my second year was amazing. She was a Harvard kid. I remember it was the first time I heard of all these schools...” - Mira

“[Mark]...wrote a letter of recommendation for me ...[Mira] (my counselor at the time) walked me through the process of applying to college and made me aware of things like FAFSA” – Anahi

“I credit math camp with a lot. I cannot imagine that I would be the person that I am today without camp... That I would be the teacher that I am today without camp” – Mira

“it wasn't until after Math Camp that I started gushing about math... access this whole other side of me. Like, I love sci-fi, I love all of these other things, computers” – Samara

The above comments show that RSMC impacted the decisions that the participants ended up making about their future, thereby impacting their higher education/career trajectories. RSMC was able to do this by expanding the participants' social network, providing them with role models, offering mentorship and guidance about applying to colleges, encouraging them to figure out what really interested them, respecting and supporting their choices, broadening their horizons and academic preparation, and giving them the confidence to dream bigger. Some of these findings are similar to what Eagan et al. (2013) found in their study about the impact of undergraduate

research programs in science education on the aspirations and intentions of STEM majors to pursue graduate studies in STEM. Eagan and associates (2013) conducted longitudinal study on 4,152 STEM undergraduate majors to examine the affect of the undergraduate research program. They found that participation in the research program significantly improved the participants' probability of reporting intentions to pursue graduate education in a STEM area. The authors also found that other factors that had a significant and positive association with the above included – interacting with graduate students and teaching assistants, feeling supported by faculty, spending more time studying, and having a STEM related career focus to begin with.

Eagan et al. (2013) also noted the importance of Weidman's (1989) theory of college student socialization which states that "as students become socialized into a particular environment, they may begin to be affected by the norms of that social structure...students who socialize with and compare themselves to a set of high-achieving students ...mirror the higher levels of achievement of their peers" (p. 688). This suggests that one's learning environment plays a crucial role in affecting one's educational and career aspirations even if one is lacking academically successful role models in his/her immediate family circle. This discussion corresponds to the findings in this study, where the participants were socialized into the norms of the RSMC environment. They found themselves surrounded by examples of motivated, driven, and successful individuals, which inspired them to broaden their horizons.

Robinson and Harris (2014), in their article 'Parental Involvement Is Overrated,' discuss the findings of their study regarding the impact of parental involvement on children's academic success. These authors suggest that the best kind of involvement is

for parents to communicate the value of schooling and going to college to their children starting early on and reinforcing this message over time. But what if one's parent's aren't well educated and do not move in such circles? How might they reinforce such a message and provide academically successful role models for their children? This is where Weidman's (1989) model proves helpful. By exposing their children to learning communities such as RSMC where faculty and peers can serve as role models and the community's resources provide the necessary information (such as applying to colleges, financial resources available to pay for college etc.); parents may be able to help their children realize their educational and career aspirations.

### **College experience for two of the participants**

Upon leaving RSMC both Mira and Samara were set on their paths of becoming a math teacher and a computer scientist or engineer respectively. They both decided to pursue their higher education at one of the top-ranked schools in the US, University C. Mira entered University C in the year 2001 as mathematics major while Samara joined it in the year 2005 as a computer science and math major. However, both girls felt that they were marginalized from their initially chosen STEM majors at University C.

Mira reported a negative experience with her calculus professor and felt that she was discriminated against. While she was doing really well on her homework and attending every office hour her TA offered, she couldn't understand why she was doing so poorly on her exams. She tried to reach out to her professor for help. However, instead of providing support and helping Mira understand what she needed to do to perform well in his class, the professor completely shut her out in a way that fractured her math learning identity. By telling her "not everyone can be an engineer," the professor was

sending her a message to quit. Mira's pride and dignity were hurt by this negative experience and she was unable to find someone whom she could turn to for help. Since this was the only professor who was assigned to teach the entire calculus series and not wanting to prolong this hurtful experience, Mira decided to quit math. In this way Mira felt marginalized and she felt that she was "weeded out."

Samara had a similar negative experience in one of the advanced math classes she took as a freshman in college. Samara felt intimidated in a setting in which she was the only person of color and one of two women in a class of 40 students. Her peers did not include her in any of the study groups and neither her professor nor her TA reached out to help. Although no one said anything to her directly, the actions of her peers, professor, and TA discouraged Samara in many subtle ways. Having limited social capital at home, not knowing how to articulate her experience to her professor, and not wanting to be labeled by her peers as a person who needs a "handout" for asking for help, Samara did not know who to turn to for guidance and felt helpless. This experience ingrained in Samara that perhaps STEM was not a field for her. By excluding Samara and not reaching out to her or guide her and offer support, a community at University C played a major role in marginalizing this young black girl from a field she considered to be her passion. These findings echo some of the similar experiences reported by black students in work of McGee (2015). The author analyzed the experience of 23 high-achieving African American college students in STEM fields. In her article, 'Robust and Fragile Mathematical Identities: A Framework for Exploring Racialized Experiences and High Achievement Among Black College Students,' the author reported on the experiences of two of black students, Tinesha and Rob, and how these two "students maintained high

levels of academic achievement” in their chosen STEM fields “while enduring marginalization, stereotyping, and other forms of racialization” (McGee, 2015). Both participants, Tinesha and Rob, in McGee’s (2015) study reported negative experiences in their respective college environments. Tinesha “described her transition to college as turbulent” and reported being “a racial minority on campus and in her discipline as well as one of the few women in her discipline” (p. 609, McGee, 2015). Tinesha felt that some of her colleagues wouldn’t give her “the time of the day” at work and her peers often asked her insulting questions. She also reported that she constantly felt that her professor and peers did not think that she belonged in the class and stated “And if you ask me for instances, I can give you a couple, but more really, it’s the looks they give me. I know I’m not crazy. And [I] see them looking at me and they are saying, “You don’t really belong here” (p. 618, McGee, 2015). This experience described by Tinesha in McGee’s (2015) work is similar to the lack of diversity that Samara reported in her advanced math class at University C as well as the feeling of being excluded by her peers that she experienced. Furthermore, Samara was also told by her peer at University C that the only reason she was accepted at the university was because she was black and a girl. This was the same peer from RSMC who had made a similar comment to Samara at camp. On the other hand Rob from McGee’s (2015) study reported a negative experience with his mathematics professor who asked him if he knew any “good cleaning ladies or maybe one of your relatives might be in a need of a job” (p. 613, McGee, 2015). Rob was hurt by the stereotypical views of his instructor, but felt that “as long as his intellectual competence was not questioned, he could put up with smart fools making racially stupid assumptions.” (p. 614, McGee, 2015). Similar to Rob, Mira also reported a negative

experience with her math professor whose remarks unlike Rob's teacher did question her intellectual competence and communicated to her in a very direct manner that only certain people can be successful in STEM. McGee (2015) reports in her study that although the negative experiences at college were emotionally draining and these experiences challenged Rob and Tinesha's academic well-being, nonetheless their effect was impermanent. This was due to a set of "healthier strategies" that her participants developed to "endure racism and color bias" (McGee, 2015). Unlike, Rob and Tinesha, Mira and Samara were not able to develop effective ways to deal with the subtle and overt instances of discrimination that they experienced. As a result both Mira and Samara felt that they were marginalized from pursuing their initially chosen STEM careers. Some of the questions that Mira and Samara's experiences at University C raise include - what is the responsibility of the learning institutions in ensuring success for all of their students? If Mira and Samara did not know how to reach out for help, who should have made it their business to mentor these girls and reach out to them first? How many students like Mira and Samara are marginalized from STEM due institutional practices that leave such students unsupported in challenging and some times hostile learning spaces? And how can STEM programs such as RSMC play a role in preparing students to deal with possibly non-supportive environments?

### **Research question 3: RSMC learning environment - practices/components valued and suggestions for improvement**

Common practices or components that were valued by all four participants in the past when the participants were campers or counselors at RSMC include – help and mentoring received from the counselors, the experience of being a counselor themselves,

teaching practices at camp, study groups, and the camp curriculum. Assessing their RSMC experience years later as mature adults, all four participants described their big take-away from camp as a sense of community (experienced slightly different from each other) and teaching practices at camp. Common practices or components that were valued by at least three participants at present include: (1) study groups, (2) mentorship received from the camp director, (3) the help and mentoring received from the counselors, (4) social aspects (e.g. weekend trips), (5) exposure to life on a college campus, (6) the camp curriculum, (7) teaching practices at camp, and (8) a sense of community. The practices listed above are not in any weighted order. Participants from other informal STEM programs reported similar aspects of such programs that they valued. For example, Fadigan and Hammrich (2004) examined educational and career trajectories of a sample of 152 female participants of an informal science program, WINS. The authors found that the social opportunities such as mentorship received from teachers and staff, socialization with like-minded peers, a safe and stable environment provided by WINS program lead to feelings of greater competency in STEM learning, enhanced resilience, and improved sense of self-efficacy. These findings are similar to some of the characteristics reported in my study by the participants as important to them. For example, mentorship, learning within study groups, social aspects (socializing with like-minded peers), and a sense of community that included the aspect of a safe environment were reported as important factors influencing the participants' learning, self-confidence, and sense of belonging at RSMC. In another study, Frost and Wiest (2007) examined how girls from diverse backgrounds perceived the characteristics of a math and technology summer camp and its impact on their confidence in understanding math. The authors indicate that the girls in

their study reported teaching methods, curriculum, and peer interactions as some of the characteristics of the camp that positively impacted their confidence in their math skills and in helping them understand math. Similarly, Morrow and Schowengerdt (2008) conducted a case study involving 12 women participants in order gain an in-depth understanding of the SEARCH program (a university affiliated math and engineering residential camp) to determine the factors that affected pursuit of higher-level mathematics by its participants. The authors found that the important factors reported by the girls in their study which helped to maintain their interest in advanced mathematics included – developing a mathematical voice (i.e. learning to explain one’s thinking and feeling comfortable with expressing ideas), gaining a broader view of mathematics, being challenged in a supportive atmosphere, and learning to develop a positive attitude towards taking risks. The practices reported as valuable by the participants in my study confirm the aforementioned past findings. For example, gaining a broader view of mathematics is described as an aspect of the camp curriculum, being challenged in a supportive atmosphere and encouragement towards taking risks are described as part of teaching methodology and mentorship at RSMC. Similarly, developing a mathematical voice or feeling comfortable with expressing one’s ideas are also reported as an aspect of a safe learning environment where making mistakes is encouraged and is viewed as part of the process of learning. In addition, the practices or components of RSMC that were valued by the participants in my study also extend the past findings. For example, the impact of the practices of RSMC on the participants is deeper than gaining confidence in doing mathematics. When describing a sense of community at RSMC, all four participants described RSMC as “more than just an academic experience”. They found

learning at RSMC to be “transformative” and the experience “life-changing.” The findings in my study also differ from the past findings reported in the camp related studies above. For example, none of the aforementioned studies report on any areas of improvement for the camps from the perspective of their participants. In my study, however, we also noted in the case of Samara some of improvements that were suggested for RSMC to make this experience even more valuable for future campers. Some of the suggestions offered by Samara for improvement include – recruiting more campers from certain minorities such as Blacks and Hispanics and more women campers from these minority groups, having the director of the camp more formally convey the equity oriented vision of the camp to all campers, and inviting guest speakers who highlight the history and contributions of women and people of color in math and other STEM areas.

Identifying the characteristics/practices of RSMC that the participants report as important to them as well as noting the suggestions for improvement helps in establishing an equity framework (described later) for informal programs in particular, and learning environments in general.

## **Implications**

In this section I discuss some of the lessons learned from and implications of this study. I organized these lessons and implications into three main categories – theoretical implications, implications for learning settings, and policy implications for supporting informal learning programs.

### **Theoretical implications**

This study highlights the importance of the theoretical framework using the ecological perspective (Tower & Hunter, 2010; Boaler & Greeno, 2000) and stitutive

theory (Greeno & Gresalfi, 2008) in impacting learning and identity construction. The findings of this study show that the same group of individuals went from being received knowers and from being positioned into a passive role when it came to learning math in their middle school and high school math classrooms to taking up an active role in their learning and constructing their own knowledge at camp. The interactive relationship between the learner (what he or she brings to the interaction) and the resources and opportunities afforded to the individual by the learning environment as a result of this interaction plays an important role in shaping how students develop conceptions of learning and of themselves as learners in a practice. The analysis of the data highlights the usefulness of the identity resource model developed by Nasir and Cooks (2009) in studying how learning settings offer material, relational, and ideational resources for the development of practice-linked identities among students. This model proved particularly helpful in operationalizing the construct of MLI within the context of the ecological perspective. The findings have implications about the central role that relational resources play in the co-construction of practice-linked identities. For example, the relationships that the participants developed with their peers, counselors, the camp director, and their teachers played a central role in helping the participants access and take up the ideational and material resources that were offered to them at RSMC. The role of these relationships in identity development was best studied using the identity resource model.

### **Implications for learning settings**

The study has implications for the potential of informal programs such as RSMC serving as spaces that can have a fundamental transformational impact on students' learning identities by providing a network of support structures.

The findings of this study have implications for pedagogical practices that operate within different learning settings. The participants in this study reported having a very narrow and ritualistic view of mathematics in didactic learning settings where they described memorization of procedures to obtain high scores on tests and often working in isolation were central practices. The same participants then described experiencing a shift in their views about mathematics and their conception of learning at camp. They described gaining a deeper understanding of what constitutes the realm of mathematics and learning at RSMC, where discussing different ideas, questioning procedures, thinking creatively, working in collaboration, and taking the time to productively struggle with a task to develop internal understanding, were central practices. This suggests that pedagogical methods that treat mathematics as disconnected topics, teach it through repeated practice of mathematical procedures, exclude students from the process of negotiation to construct their own learning, and place high stakes on test scores may be detrimental to students' understanding of mathematics and of learning. Furthermore, teaching practices that are based on discussion of concepts, questioning procedures, and collaboration among students and teachers may be more helpful in developing understanding of mathematics and what it means to learn something.

The findings of this study have implications for the potential of alternative spaces such as RSMC “which can serve to counter some of the dominant narratives about who is capable.” For example, Mira, Anahi, and Hima were able to construct broadened perspectives on learning and success by confronting their deficit or fixed ability views at camp. They were able to do so because they witnessed the equity-based vision of RSMC transpire within a truly diverse body of campers. These findings have implications for

increasing diversity and for critical mass theory (Powell, 2012). In the earlier discussion I tried to make sense of why Anahi, Hima, and Mira were able to disrupt their stereotypical views whereas Samara was not. This was done by looking at the demographic data during the years when each girl attended camp. The discussion highlights the importance of a critical mass when creating diverse learning settings.

The study also has implications for college learning environments where students from non-traditional backgrounds may find themselves in non-diverse settings without any support. It is imperative that institutions of higher learning offer support structures for all of their students. However, just having support structures such as tutoring labs may not be sufficient. Sometimes support structures have an implied unspoken deficit message attached for those who choose to make use of these resources. For example, Samara didn't want to ask for help from her professor because she didn't want to be perceived by her peers as a person who needs a handout. She was already told by one of her peers that the only reason she got into a school like University C was because of affirmative action. On the other hand when Mira did go to her professor for help she was told in a very direct manner that only certain people are capable of pursuing STEM. So, what then is the responsibility of the institution towards students like Samara and Mira? It is imperative for places of higher learning to effectively educate the student body and faculty on issues of gender and race. This education and communication needs to be actively done to dismantle racial and gender storylines that may and do exist in college learning settings. Informal programs such as RSMC can also play a crucial role here by counseling their students about encountering such issues in other learning settings and preparing students to learn about strategic ways to navigate such spaces.

### **Policy implications**

The findings of this study show that programs like RSMC significantly influence the decisions that students end up making about their future thereby impacting their higher education/career trajectories. All four participants in this study reported the impact RSMC had on their higher education and career choices. For example, it was at camp that Mira decided that she wanted to become a math educator just like her camp teachers; Samara discovered her love for computers and math at RSMC during the Mathematica course that she took at camp; Hima was encouraged at camp to figure out what really interested her which turned out to be medicine; and Anahi received guidance on how to realize her dream of becoming an engineer. The participants also reported how RSMC increased their SC and helped them get into some of the top-ranked colleges in the nation to pursue their dreams. In this way informal programs like RSMC can serve as a pipeline for increasing a talented and diverse student population at selective institutions of higher learning.

The findings of the study show that programs like RSMC provide a transformational experience for the students. The participants in the study described the camp experience as life changing in many ways. Communities like RSMC tend to impact not just a student's learning but their holistic sense of self and worldview. Therefore, avenues like RSMC need to be supported and funded by federal, state, local, and private sources so that they can recruit students from underprivileged areas on full scholarship and offer them unique transformative learning experiences.

## Equity Learning Settings Ally (ELSA) Framework

Based on the findings and implications of this study I propose a framework for establishing an equity based education model aiding in the construction of positive, holistic, and broadened learning identities. The figure below provides a pictorial representation of the ELSA framework.

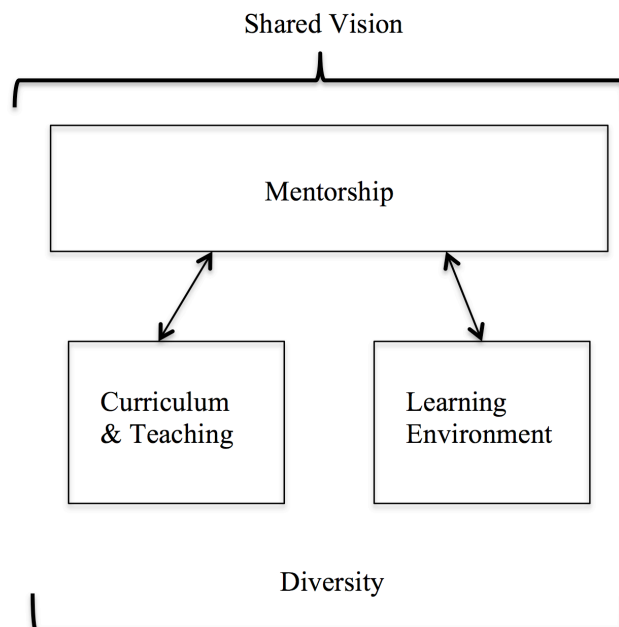


Figure 42. ELSA Framework

The above framework applies to informal math programs and can be extended to other learning settings. There are five components that are essential for ensuring a community of practice that is founded on equitable principles to provide a nurturing environment for all students:

(1) *Shared vision founded on equity* - any learning setting whose aim is to provide equitable learning to all needs to have a clear vision based on equitable principles. Based on the findings of this study, I suggest that this vision should incorporate the following core values: (a) understanding historic inequities helps us educate ourselves and gives us

courage to strive for a just community; (b) everyone irrespective of their background has something valuable to contribute; (c) a diverse environment based on mutual respect benefits everyone; (d) learning is a transformative experience; and (e) a learning environment should nurture its students and foster a growth mindset. The equity-based vision must be enacted and modeled by all members of the learning community for it to be effective. Continual evaluations of the vision and the practices of the learning setting are also essential.

(2) *Mentorship* – a network of structures that encourage mentorship at different layers throughout the duration of a program is an essential component of the framework. For example, RSMC has several layers of mentorship that serve as a support structure for the new and returning campers such as counselors, teachers, camp director, journaling, and administrative staff. Counselors at RSMC take on the role of a mentor and a teacher. They help campers with their coursework like a teacher, mentor them about any personal issues, and guide them about their future career or higher education choices. The structure of the camp is such that every camper has an assigned counselor who interacts with her/him everyday. The counselors themselves are mentored by the camp director through regular meetings and through the practice of counselor journaling. Teachers at RSMC are approachable and often mentor students about their studies and future plans. The practice of journaling serves as a student support activity through which the students can communicate any issues they may be experiencing directly to the RSMC director. It is an important step in building a strong and meaningful relationship with the camp director, who serves as a mentor to the students and provides personal counseling and guidance to each camper. This practice affords a necessary and valuable relational

resource to RSMC students and the camp director to nurture the campers' learning identities. Furthermore, mentorship through journals is built into the structure of RSMC and unavoidable by campers. Therefore, students don't have to go looking for help; the practice allows for reaching out to the students even if they don't know how to ask for help. Similar structures need to be established in any learning setting that seeks to make a difference in the learning of their students.

(3) *Curriculum and Teaching* – a learning setting will usually establish a series of topics to cover based on some criteria. However, the tasks or problem sets designed to cover these topics should be multidimensional, challenging, and enriching. Some of the characteristics of such tasks include being open-ended and exploratory, allowing for multiple entry points, allowing students to grapple with uncertainties and ambiguities, encouraging students to question facts and procedures, fostering critical and creative thinking, and motivating students' curiosity. Good teaching practices that are rooted in research such as NCTM's Principles and Standards (2000) are an essential component of any learning setting. Some of these teaching methods include giving students agency, helping them take ownership of their work, emphasizing the joy in the process of learning itself, having students generate ideas and questions, helping students feel comfortable with uncertainty and taking risks, valuing multiple perspectives and discussion, creating a classroom culture where students feel unafraid to make mistakes and where failure is seen as an opportunity to learn something new, having high expectations from all students, and allowing for self-paced learning.

(4) *Diversity* – creating a diverse learning setting with an eye towards critical mass is beneficial for everyone. For example students who experience racial and ethnic diversity

in educational settings become better learners and more effective citizens (Gurin et al., 2002). Several studies (e.g. Hurtado, 2007; Hurtado, et al., 2003; Gurin et al., 2002) have provided evidence for benefits of diverse learning settings on students' academic learning, personal and social growth, and civic education. Therefore, creating a diverse learning environment is critical for an equity-oriented learning setting.

(5) *Learning environment* –Informal programs or other learning settings should incorporate certain semi-structured components in which the curriculum, teaching practices, and the vision of the community are enacted. For example, RSMC has the following structures in place for the aforementioned purpose: Morning classroom lectures, study groups, problem sessions, colloquiums, non-academic team building activities, and mentorship structures. At RSMC the study group component allows for learning to be discussion based and student directed. The counselors aim to ensure that the study group sessions foster camaraderie among group members and create an environment of mutual support to provide a team-building experience. This structure also allows for students to spend enough time to struggle with the problems in a supportive environment. A detailed description of the RSMC structural components can be found in Chapter 3. These structures may be used as a guide for other learning settings and can be adapted to suit the unique organization of other environments.

### **Directions for Future Research**

The findings and implications of this study have raised questions for future research. I will discuss below some of the questions in detail that I think are important for researchers to consider.

(1) How do African-American participants of informal math programs such as RSMC envision the program's influence on the construction of their mathematical learning identity? How do these participants envision the impact of such programs on their higher education and/or career trajectories in STEM areas?

This would help us better understand the impact informal programs can make in the learning and career trajectories of African-American students. Samara's case presents important findings to merit such a study. Studying the identity construction process among African-American students requires research into understanding what it means to be an African-American in a society where racial storylines are prevalent in every setting. It also requires understanding the historic legacy of African-Americans in this country and using this understanding to unpack the complex identity construction process among African-American students in alternate learning spaces. Nasir et al. (2012) consider the potential of alternative spaces in helping students counter some of the dominant narratives in society. We saw that this happened for three of the four participants in this study and was an important aspect of their MLI co-construction. Therefore, investigating the role that informal programs can play in helping African American students counter dominant storylines will be an important undertaking. We note that it has been difficult for RSMC to recruit students from the African American demographic consistently over the years, as is the case for many institutions. Therefore critical mass has not been consistently achieved at RSMC with respect to this demographic. This finding contributes to some of the continuing challenges for informal programs such as RSMC as well as other learning institutions for figuring out ways to build pipelines to diverse communities

in order to increase student enrollment from the African American demographic. This presents an avenue for future research in investigating efforts that result in increasing diversity at an institution. Perhaps, telling the stories of African American students who attend informal programs and how they envision the impact of such programs on their higher education/career trajectories might be a start.

- (2) What are the experiences of students from non-dominant backgrounds in highly selective institutions of higher learning? What roadblocks do these students encounter at such learning settings, if any? How do these students navigate through the challenges that they face in college?

The findings of Mira and Samara highlight the systemic biases that are present in some of the top-ranked institutions of higher learning and merit further research on the questions I proposed above. It is important to tell the stories of traditionally marginalized students who attend such institutions. The study will help institutions evaluate their practices and establish structures to support all of their students in more equitable ways. Furthermore, such a study would be important for non-dominant students to see that they are not alone, others have gone through similar experiences, and learn about some of the ways to navigate through institutional practices without letting them create permanent academic and career damages.

- (3) How can informal programs like RSMC as well as other learning institutions help educate their faculty and student body about the issues of gender and race that are prevalent in our society, have powerful implications for learners, and are a critical aspect of life in educational settings?

The findings from Mira and Samara's cases merit further exploration of the above question. In Samara's case we had noticed that she encountered a peer at RSMC who made negative comments about her race and gender. The same peer when he met Samara again at college made similar remarks to her. Similarly, Mira encountered a college math professor who she felt displayed bias against women or minorities. The findings from Mira and Samara's cases warrant an exploration into finding effective ways in which learning settings can better educate their members about such issues. Nasir et al. (2012) raise the aforementioned points in their article 'Racial Storylines and Implications for Learning.' The authors also consider the role that out-of-school settings can play "to support students in developing adaptive counter-narratives, which allow them to reject the common negative racial storylines, reauthor their identities in positive and productive ways, and engage in learning settings more deeply" (p. 288, Nasir et al., 2012). Therefore, exploring ways in which informal programs such as RSMC can prepare students to deal with possibly non-supportive environments would also be beneficial.

I proposed the ELSA framework for establishing an equity based education model aiding in the construction of positive, holistic, and broadened learning identities. I would like to encourage other researchers to investigate how this framework can be used to study different learning settings such as other informal programs, school environments, and colleges. Efforts to increase and sustain diversity at learning institutions requires prolonged commitment and I am hopeful that the future will only bring more educators who are committed to making a difference and establishing learning settings where everyone can grow and learn.

## APPENDIX SECTION

### APPENDIX A: RSMC Alumni Preliminary Survey Questions

We'd love to know how the [Riverside Summer Math Camp] experience has impacted your education/career trajectory! Thank you for taking 5-10 minutes to fill out the 15-question survey below! Results from this survey may be used as part of a research project on mathematics education and for [RSMC] publicity materials. If you have any questions regarding this survey, please feel free to contact [...]

Required\*

1. Your full name\* \_\_\_\_\_
2. Gender\* \_\_\_\_\_
3. What is the highest level of education attained by your father? (Choose from the list)
  - a. Some high school
  - b. Finished high school
  - c. Associate's Degree
  - d. Bachelor's Degree
  - e. Graduate/Professional Degree (Master's, Ph.D., MD, JD, etc.)
  - f. Other (explain) \_\_\_\_\_
4. What is the highest level of education attained by your mother? (Choose from the list)
  - a. Some high school
  - b. Finished high school
  - c. Associate's Degree
  - d. Bachelor's Degree
  - e. Graduate/Professional Degree (Master's, Ph.D., MD, JD, etc.)
  - f. Other (explain) \_\_\_\_\_
5. What is your father's main occupation (if retired, please write down their occupation before retirement)
6. What is your mother's main occupation (if retired, please write down their occupation before retirement)
7. During middle or high school, were you ever eligible for free or reduced lunch?\*\_  
\_\_\_ Yes; \_\_\_ No
8. Are you a first generation college student?\*\_ \_\_\_ Yes; \_\_\_ No
9. Please check ALL math courses you took before college\*
10. When did you take Algebra 1?\*\_ (choose from the list)
11. Please list the major of your bachelor's degree (Leave blank if not applicable)\*
12. Please list the major of your graduate/professional degree (Leave blank if not applicable)\*
13. Please list your employment/vocational/internship history after college\*
14. What aspects of the [RSMC] experience were influential in making your subsequent education/career choices?\*
15. Any additional comments on your Math Camp experiences?

## APPENDIX B: Participant Interview Questions Guide and Rationale for the questions

This interview will be audio-recorded and later transcribed. Pseudonyms will be used when transcribing the interviews and later citing the excerpts of the transcription in the write up of the researcher's dissertation or any other research papers that she chooses to publish using this data.

Interview question	Purpose	Answering of this question help me answer which parts of my RQs?
<b>Interview PART I</b>		
<p>1. Think back to the time prior to joining RSMC, at that time what did you think mathematics was?</p> <p>Follow up: Did you like math? If so, why or why not?</p> <p>2. Describe what you thought "learning" or "doing" mathematics meant or entailed?</p> <p>Follow up: How would you distinguish your peers who were successful in math from those were not in your HS/MS?</p> <p>Follow up: Did you ever used compare your math skills to the boys in the class? How so?</p> <p>How did the boys generally tend to behave in your math class?</p> <p>Follow up: Was speed ever an issue for you during this time like did it matter if you were the first one to finish a test or a quiz in your class?</p> <p>Follow up: Was speed more</p>	<p>To get information about the participant's perception of math as a subject and the type of MC (<i>her ways of knowing</i>) the participant thought she had before attending RSMC.</p> <p>To get information about how being good at math was perceived and gendered narratives.</p> <p>Narratives of speed vs performance, memory vs understanding</p>	<p>Helps in answering RQ 1a and RQ 1b.</p>

<p>important than accuracy or performance?</p> <p>Follow up: what did you think the role of memory was in learning math in general at that time?</p> <p>What was your opinion of how math should be learned in order to be successful in your math classroom in HS/MS?</p>		
<p>3.From what you recall, please describe how learning took place in your math classes in your high school (e.g. <i>what did the teacher do? What was expected from you? What was the environment like? What did you remember doing? What was your normal routine? etc.</i>)</p> <p>Follow up: How did it make you feel?</p> <p>Follow up: Describe your relationship with your teacher.</p> <p>What did you think of his/her teaching style? (e.g. Were you perfectly at ease with what your teacher did or did you ever question his/her methods of teaching?)</p> <p>Follow up: How was the atmosphere like in your school regarding the standardized tests?</p> <p>Follow up: How did this affect your math classrooms?</p>	<p>(1)To get information from the perspective of the participant about the <i>figured world</i> of math learning environments different from RSMC.</p> <p>(2) To get information about the feelings that standardized testing produced in the school in general and the participant in particular.</p>	<p>Helps in answering RQ 1a and 1b. In order to determine the impact of RSMC, I must first find out what other learning environments were like for the participant before coming to RSMC.</p>

Follow up: How was your experience with this test?		
<p>3. What made you join RSMC?</p> <p>Follow up: How did you hear about it?</p> <p>Follow up: What were your expectations from RSMC before you started the camp? (For e.g. <i>what did you think this camp would do for you?</i>)</p> <p><i>What type of math did you think you were going to learn at the camp?</i></p> <p><i>What did you want from it? What did your parents/guardians want from it?)</i></p>	To get information about what the participant expected from RSMC based on her pre-RSMC MLI & SC	Helps in answering RQ 1.
4. From what you recall, please describe the courses that you took at RSMC i.e. the lessons, instruction, environment etc. How was “learning” or “doing” mathematics accomplished at the camp generally?	To get information about the <i>figured world</i> of math learning environment of RSMC from perspective of the participant and how they were positioned in RSMC.	Helps in answering RQ 1a and 1b. In order to note the impact of RSMC, I must find out how the learning environment of RSMC was different, if at all, for the participant in her own words.
<p>5. After each summer of camp, when you returned back to your high-school, what did you feel about your knowledge and skills in math?</p> <p>a. Did you take any upper level math classes?</p> <p>b. At that time did you think camp had anything to do with your decision to take upper level math classes in HS? If so, what?</p> <p>c. How did your views</p>	<p>(1) To get information about perceived growth/change in participant’s MC aspect of MLI during/soon after RSMC in her words</p> <p>(2) To find out in her words the impact of the camp, if at all, on her <i>ways of knowing</i>, her decisions to take advance math due to improved MC</p>	Helps in answering RQ 1

change, if at all, about what it meant to <i>do</i> or <i>learn</i> math? Please provide a comparison of this with what your views <i>were</i> about learning math <i>before</i> RSMC.		
<p>6. As you look retrospectively on your RSMC experience now in hindsight,</p> <p>a. what views do you hold about how RSMC impacted your proficiency in mathematics, if at all? How do you know this? or How do you think RSMC did this?</p> <p>b. what type of knowledge and skills in math you think that RSMC intends to develop in its campers? How?</p>	<p>(1)To get information about participants' views about the impact of RSMC on their MC aspect of MLI now when they look at their experience in retrospect.</p> <p>(2) To get information about how the participants perceive RSMC in relation to developing MC for all.</p>	Helps in answering RQ 1
<p>7. Earlier we were discussing how learning took place in your math classes in your high school. Now think back to that time again (<u>this is before you started RSMC</u>) and from what you recall,</p> <p>a. Describe to me what you thought your role was in learning mathematics i.e. what was expected from you as a student in your math classes in HS/middle-school?</p>	<p>(1)To get information about the positioning(s) of the participant in the <i>figured world</i> of math learning environments different from RSMC that shaped the nature of her MLI – perceptions as a learner before attending RSMC</p>	Helps in answering RQ 1
<p>7b. At that time what did you feel about your knowledge and skills to learn math? Why?</p> <p>i. How did it make you feel when you were able to solve a problem? How did it make</p>	<p>(2)To get information about participants' mindset (growth vs. fixed) before attending RSMC</p>	Helps in answering RQ 1

<p>you feel when you were not?</p> <p>ii. If you did well in school on a math test or homework for example, what reasons would you attribute to that success?</p> <p>iii. If you did not do so well in school on a test or an assignment, what reasons would you attribute to that experience?</p>		
<p>7c. How did your teachers and peers in your math classes in HS/middle-school see you as a student of mathematics? How do you know?</p> <p>i. Follow up: How did that make you feel?</p>	<p>(3)To get information about how perceptions of others were affecting the participant's (1<sup>st</sup> P) MLI (<math>_{B}A_A</math> and <math>_{B}A_C</math> affecting <math>_A A_A</math>) prior to RSMC</p>	<p>Helps in answering RQ 1</p>
<p>7d. Describe your relationship with the subject of mathematics during <u>this</u> [prior to RSMC] time.</p> <p>i. Did you work on extra math problems (besides the ones assigned as homework) in your spare time? Why?</p> <p>ii. What did <i>your parents or guardians</i> think about math as a subject?</p> <p>iii. What did <i>you</i> think about math as a subject?</p> <p>iv. Did you like (dislike) math or the idea of math during this time? Why?</p> <p>iv. How important learning mathematics was for you during that time and for what reasons?</p>	<p>(1)To get information about participants' feelings towards math and how important math was to them <u>prior</u> to RSMC which would reflect in part the nature of their MLI at that time.</p>	<p>Helps in answering RQ 1</p>

<p>8. Earlier we were discussing how learning took place in RSMC. Now think back to that time again (<u>this is during or after RSMC</u>) and from what you recall,</p> <p>a. Describe to me what you thought your role was as a student in learning mathematics i.e. what was expected from you as a student in your camp classes?</p>	<p>(1)To get information about the positioning(s) of the participant in the <i>figured world</i> of math learning environment of RSMC that shaped the nature of her MLI</p>	<p>Helps in answering RQ 1</p>
<p>8b. At that time what did you feel about your knowledge and skills to learn math? Why?</p> <p>i. How did it make you feel when you were able to solve a problem during your camp classes in study groups or alone?</p> <p>Follow up: what was this due to?</p> <p>ii. How did it make you feel when you were not?</p> <p>Follow up: what was this due to?</p>	<p>(2)To get information about any change participants' mindset (growth vs. fixed) during/after RSMC</p>	<p>Helps in answering RQ 1</p>
<p>8c. How did your teachers at RSMC see you as a student of mathematics?</p> <p>Follow up: How do you know?</p> <p>Follow up: How did that make you feel?</p> <p>How did your peers in your camp classes or your study group and counselor see you as a student of mathematics?</p>	<p>(3)To get information about how perceptions of others were affecting the participant's (1<sup>st</sup> P) MLI (<math>_{B}A_A</math> and <math>_{B}A_C</math> affecting <math>_A A_A</math>) during RSMC</p>	<p>Helps in answering RQ 1</p>

<p>Follow up: How do you know?</p> <p>Follow up: How did that make you feel?</p>		
<p>8d. Describe to me your experience of working in a study group each summer at RSMC.</p> <p>i. I'd like you to describe to me what actually happened and how did learning take place, how did these solving of problems in the groups take place?</p> <p>Follow up: Was it really individually? Or Was it the group dynamics?</p> <p>Follow up: How did the group interactions work?</p> <p>ii. Also describe what role your counselor played in your study group.</p> <p>iii. How did working as part of the study group and participating in problem sessions make you feel about yourself as a student of mathematics?</p> <p>Follow up: How were these feelings different from what you felt about yourself before coming to RSMC and how were they the same?</p> <p>iv. Besides working on problem sets for your camp classes, what else did you and your study group mates do?</p> <ol style="list-style-type: none"> <li>1. How did this experience affect (did not) you as a person?</li> <li>2. How was this experience different or</li> </ol>	<p>(1) To understand the structure of study groups in participants' own words</p> <p>(2) To explore how the experience of working over the whole summer as part of a <u>study group structure and participating in problem sessions</u> at RSMC affected the participant's MLI (1<sup>st</sup> P)</p> <p>(3) To get information about a change (if at all) in participants' feelings about being a student of math during/after attending RSMC</p>	<p>Helps in answering RQ 1</p>

same when compared to hanging out with your peers at your HS/middle-school back home?		
9. After attending each summer of RSMC, when you returned back home, how were you viewed by others (parents, teachers at HS, peers HS) as a students of mathematics?	To get information about how perceptions of others in the old environment were affecting the participant's MLI after they attended RSMC i.e. how did RSMC experience contribute to shaping their MLI (1 <sup>st</sup> P)	Helps in answering RQ 1
10. What did you think about yourself as a learner of mathematics <u>after each summer of attending RSMC</u> ? i.e. describe your relationship with the subject of mathematics during this time.  i. Did you work on extra math problems (besides the ones assigned as homework) in your spare time? Why?  ii. Did <i>your</i> views about math as a subject change? How?  iii. How important learning mathematics was for you during that time (i.e. during and after RSMC) and for what reasons?	(1)To get information about the nature of participants' MLI during/after RSMC experience;	Helps in answering RQ 1
11. Did you ever think of yourself as different because of your gender? How so?  Did you ever think of yourself as different because	(1) To get information about how the self-perceptions regarding a learner of, or participant in, mathematics relate to the participants' membership in a larger societal group such as	Helps in answering RQ 1

<p>of your ethnicity and/or class? How so?</p> <p>Follow up: Did these feelings ever carry over to your math classes in MS/HS prior to RSMC?</p> <p>Follow up: were they the same or different i.e. how did they affect your perception of yourself as a learner of, or participant in, mathematics?</p> <p>Follow up: Did these feelings ever carry over to your math classes at the camp?</p> <p>Follow up: how were they the same or different i.e. how did they affect your perception of yourself as a learner of, or participant in, mathematics?</p> <p>Follow up: Did the changes carry over past math camp? How so?</p>	<p>gender, ethnicity, and class.</p> <p>(2) To get information about how the experience at RSMC affect these self-perceptions, if at all.</p>	
<p>12. As you look retrospectively on your RSMC experience now in hindsight,</p> <p>a. What views do you hold about how RSMC impacted your perceptions of yourself as a student of mathematics, if at all?</p> <p>Follow up: How do you know this? or How do you think RSMC did this?</p> <p>b. What type of beliefs or perceptions with respect to being a student of mathematics, you think that RSMC intends to develop in its campers? How?</p>	<p>To get information about participants' views about the impact of RSMC on their MLI now when they look at their experience in retrospect</p>	<p>Helps in answering RQ 1</p>

Interview PART II		
<p>13. What did you want to be or study when you grew up before coming to RSMC?</p> <p>Follow up: What made you want to do that?</p> <p>Follow up: Who gave you advice, offered opportunities regarding your future plans?</p>	<p>(1) To get information about pre RSMC career/educational aspirations and resources in the social network who may have helped shape these aspirations</p>	<p>Helps in answering RQ 2</p>
<p>14. Did your education/career goals change during/after RSMC? Why?</p> <p>Follow up: What specific field of study did you end up pursuing? Why?</p> <p>Follow up: Did RSMC have anything do at all with your decision to pursue a STEM related higher education/career? If so, what?</p>	<p>(1) To get information about during/post RSMC career/educational aspirations, resources in the social network of RSMC who may have helped shape these aspirations, and which field did the participant actually ended up pursuing, and the role that RSMC played, if any, in the education/career choice made by the participants</p>	<p>Helps in answering RQ 2</p>
<p>15. Before coming to RSMC, what type of social network (e.g. parents, relatives, friends, acquaintances, peers, teachers, mentors, and organizations) do you recall having or your parents talking about?</p> <p>a. How did resources in this network help you towards your education/career goals, if at all? Could you give me an example?</p>	<p>To get information about the nature of SC the participant had prior to starting RSMC (human capital, initial positions, social ties)</p>	<p>Helps in answering RQ 2</p>
<p>16. What kind of sense of community did you experience at RSMC, if at all?</p> <p>Follow up: How do you think RSMC creates this sense of community?</p>	<p>To get information about sense of community that the participant experienced at RSMC which may impact her SC</p>	<p>Helps in answering RQ 1, 2, 3</p>

<p>17. After attending RSMC, did your social network grow? If so, how? i.e. How did being part of the RSMC community affect your social network?</p> <p>Follow up: Were you able to maintain this social network after graduating from the camp? How?</p>	<p>To get information about how RSMC affected the participant's Social network and did this network extend beyond the RSMC</p>	<p>Helps in answering RQ 2, RQ 3</p>
<p>18. Did you ever receive any help from your contacts (e.g. camp faculty/staff, fellow campers, camp alumni etc.) through the camp towards pursuing your educational/career goals? Or did you ever feel that you were afforded certain opportunities based on your connections at RSMC?</p> <p>Follow up: Could give me an example of the type of help or opportunities you received at RSMC, by whom, and how did it help?</p>	<p>To get information about how RSMC affected the participant's SC i.e. was the participant able to access and utilize the resources embedded in RSMC environment towards pursuing her educational/career goals and how.</p>	<p>Helps in answering RQ 2</p>
<p>19. As you look retrospectively on your RSMC experience now in hindsight,</p> <p>a. What views do you hold about how RSMC affected your social network and social capital, if at all?</p> <p>b. How do you know this? or How do you think RSMC did this?</p> <p>c. Did RSMC help you in any way to pursue a STEM related higher education/career? If so, how?</p>	<p>To get information about participants' views about the effect of certain practices and components of RSMC on their SC now when they look at their experience in retrospect.</p>	<p>Helps in answering RQ 2</p>

<p>20. Now think back to the time when you were in RSMC, what RSMC practices or components do you recall valuing at that time, if any? Why?</p> <p>a. Did any of these components influence your higher education/career choices? If so, which ones and why?</p>	<p>To identify the practices/characteristics of RSMC that campers valued and that led to the impact on their MLI and SC.</p>	<p>Helps in answering RQ 3</p>
<p>21. As you look retrospectively on your RSMC experience now in hindsight, which components or practices of RSMC would you say that you value most? Why?</p>	<p>To identify the practices/characteristics of RSMC that campers now value in hindsight and that led to the impact on their MLI and SC</p>	<p>Helps in answering RQ 3</p>

## APPENDIX C: Sample RSMC Camp Evaluation and Camp Essay Instructions

*Mathematics is a beautiful language which is best learned by constant use. – [Mark Weitzman]*

As our summer draws to an end, I would like to take a moment to say how much I have enjoyed having you all as participants in the [Riverside Summer Math Camp]. I know that I have learned a lot, and hope that you have too. I have loved to see you grow mathematically, mature, and help one another create an exciting learning environment. The ultimate value of the program depends on each student and what he/she is able to accomplish. We have not had a set amount of material that we wanted to cover. Rather, our focus has been to instill in each student the curiosity and background to continue learning after you leave. Never be afraid to make a mistake, for it is only by trying new ideas, by thinking deeply of why things work, that you will be able to discover new ideas.

I hope that you have enjoyed exploring new problems and will leave with increased confidence in yourselves and what you can each accomplish. And I hope that you have made many new friends who will continue to work together to make this a better place in which we live.

Again, my heartfelt thanks for the opportunity to work with each of you this past summer, and best wishes for a wonderful school year. Please keep in touch with me and contact me any time you have questions, problems, or just to talk. With best wishes for a happy, healthy summer,

[Mark]

### **Camp Essay.**

Please describe how this Math Camp has affected you personally. Describe your background, and your views about your own personal development this summer and your plans for the future. I am particularly interested in how this camp may have differed from other experiences you have had. These are important in helping us better understand how the program may have helped you grow and develop over the summer.

### **Camp Evaluation.**

Please write a separate evaluation of all parts of the camp—courses, teachers, counselors, colloquium speakers, weekend activities, working together in groups, etc. What did you like most? Least? Why? Please be as specific as possible. Your essays are very valuable in helping us learn what worked, what didn't, and why, so that we can continue to improve the program. Any feedback and suggestions for faculty and counselors are particularly appreciated!

### **Course Evaluations:**

Number Theory

Mathematica Lab  
Honors Seminar  
Analysis 1  
Analysis 2  
Combinatorics  
Research Topics

**Siemens Projects:**

**Problem Sessions:**

**Study Groups:**

Counselor  
Members

**Counselor(s):**

**Junior Counselors:**

**Weekend Trips (Comments on each with ratings)**

**Colloquium Speakers**

**Summary:** Finally, give your overall impressions and any additional remarks.

**Very important:** It really helps if you can describe what you liked or disliked and why. Simply saying something was “great” does not tell us what was great about it. Similarly, if you found something “terrible”, what about this did you not like. If you really enjoyed something, please let us know about that too. What, if anything, made the summer special, and would you want to return? Why? How was this program different from your usual classes? Do you feel excited about doing more math?

**Rating:** Could I also ask that you organize your **camp evaluation** in the above categories, and give each item a numerical rating corresponding to:

5 = Excellent    4 = Very Good    3 = Good    2 = Fair    1 = Poor

## APPENDIX D: Sample RSMC Problems from the Number Theory Course

### RSMC | PROBLEM SET 20

“Failure, although intrinsically less desirable than success, is often more instructive: It is a lesson to a scientist to determine how one could pass closely to an important discovery without suspecting it.

Moreover, this sort of thing occurs frequently in the history of thought.”

- Jacques Hadamard

### WEEKEND PROBLEM

1. If you have not yet done so, complete the problems labeled with a \*.
2. Please take time to complete your work on the Reduced Inventory Problem Set.

### INGENUITY

3. Can you find a knight's tour in chess, i.e., a sequence of moves by a knight which lands exactly once on each square of the chessboard?
4. In how many ways can a king in chess move from the lower left corner square to the upper right corner square if each move is either up one square, to the right one square, or one step diagonally toward the upper right?
5. A unit fraction is a fraction of the form  $\frac{1}{n}$  where  $n$  is a positive integer. These are sometimes called Egyptian fractions since the ancient Egyptians worked with them extensively.  
We see that the number 1 is a sum of distinct unit fractions:  $1 = \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$   
Can every fraction be expressed as a finite sum of distinct unit fractions?  
Compute some examples.  
General proof?
6. Is 1 expressible as a sum of distinct unit fractions all with odd denominators?  
A Mathematica search might find an answer, if one exists.

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