Title
Sister Scientist Outsider: Social Network Analysis of Women of Color STEM Majors in The Community College

Permalink
https://escholarship.org/uc/item/4n3118jw

Author
Yap, Melo-Jean

Publication Date
2018

Peer reviewed|Thesis/dissertation
Sister Scientist Outsider:
Social Network Analysis of Women of Color STEM Majors
in The Community College

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy
in Education

by

Melo-Jean Yap

2018
ABSTRACT OF THE DISSERTATION

Sister Scientist Outsider:
Social Network Analysis of Women of Color STEM Majors
in The Community College

by

Melo-Jean Yap
Doctor of Philosophy in Education
University of California, Los Angeles, 2018
Professor Megan Loef Franke, Co-Chair
Professor Louis M Gomez, Co-Chair

In feminist standpoint theory (FST), the marginal social status of women provides them a nuanced perspective; this particular standpoint of reality holds potential in producing knowledge that challenges and goes beyond the dominant point of view. Since it characterizes “relations between the production of knowledge and practices of power” (Harding, 2004), FST holds promise in magnifying the experience, power struggle, and knowledge production of women of color pursuing STEM majors and careers. This dissertation studies the networks that influence the scientific thinking of women of color STEM majors at Marvel Community College (MCC), a pseudonymized community college that is considered as a Hispanic-Serving Institution in Los Angeles, California. I used a mixed methods approach of qualitative questionnaire and social
network analysis to demonstrate how women of color students’ marginalized locations affect their knowledge production as scientists.

The questionnaire asked 35 participants about influences to five processes of scientific thinking: scientific observation, scientific explanation, scientific critique, scientific justification, and legitimization of scientific knowledge. Results show that family members influence the scientific thinking of participants the most with 150 out of 450 nominations, regardless of highest level of education completed (high school or lower level). Disaggregated gender data reveals that female relatives have the most nominations. Meanwhile, disaggregated racial and ethnic data show that Latinx relatives are the most nominated racial/ethnic group.

Female relatives represent a substantial quantum of family nominations. The matriarchal nature of the family nominees implies a gendered wisdom being passed down from generation to generation. This wisdom could be privy to matriarchs, with their unique standpoint as mothers, women of color (particularly, Latina), and oftentimes, immigrants in American society, where they traverse along the boundaries of race, class, and gender. These matriarchs pass along the privy knowledge on navigating the home and the world with their daughters--the participants who translate these valuable home lessons into the guiding lights of their evolving scientific minds. The standpoint of women of color community college STEM majors ought to be explored further, especially with the potential of community wealth capital in shaping scientific thinking, and, hence, knowledge production in STEM fields.
The dissertation of Melo-Jean Yap is approved.

Cecilia Rios-Aguilar

Kimberly Tanner

Megan Loef Franke, Co-Chair

Louis M Gomez, Co-Chair

University of California, Los Angeles

2018
This dissertation is dedicated to the struggle of my loved ones
(Taina Brown, Janet Cacdac, Julio Cacdac, Jennifer Flanagan, & the rest of my family),
to the memory of my friend Angel Temple,
& to the blessings of my ancestors (Josefina Alcedo Cacdac & Andronico Yap).
# TABLE OF CONTENTS

LIST OF FIGURES............................................................................................................. IX

ACKNOWLEDGEMENTS................................................................................................. XI

VITA................................................................................................................................. XIII

CHAPTER I: INTRODUCTION......................................................................................... 1

Statement of the Problem............................................................................................... 2

Purpose of the Study....................................................................................................... 3

Research Questions...................................................................................................... 3

Significance of the Study............................................................................................... 4

Limitations of the Study............................................................................................... 4

Chapter I Bibliography................................................................................................. 5

CHAPTER II: LITERATURE REVIEW........................................................................... 6

Empirical review............................................................................................................. 6

The Double Bind........................................................................................................... 6

Persistence..................................................................................................................... 7

Theoretical Framework................................................................................................. 10

Feminist Standpoint Theory......................................................................................... 10

Standpoint versus mere perspective........................................................................... 11

Location......................................................................................................................... 14

Black Feminist Epistemology....................................................................................... 14

Hegemonic knowledge production............................................................................. 17

Implications for Women of Color in the STEM field............................................... 18

Critical Social Network Analysis (SNA)................................................................. 20
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURE 1</td>
<td>QUESTIONS ASKED REGARDING SCIENTIFIC THINKING</td>
<td>41</td>
</tr>
<tr>
<td>FIGURE 2</td>
<td>CATEGORICAL RELATIONSHIPS OF INFLUENCERS TO SCIENTIFIC THINKING</td>
<td>43</td>
</tr>
<tr>
<td>FIGURE 3</td>
<td>SCORED COUNTS OF INFLUENCERS TO SCIENTIFIC THINKING</td>
<td>45</td>
</tr>
<tr>
<td>FIGURE 4</td>
<td>RACE/ETHNICITY OF INFLUENCERS TO SCIENTIFIC THINKING VIA RELATIONSHIP</td>
<td>46</td>
</tr>
<tr>
<td>FIGURE 5</td>
<td>INFLUENCERS TO SCIENTIFIC OBSERVATION VIA RELATIONSHIP</td>
<td>47</td>
</tr>
<tr>
<td>FIGURE 6</td>
<td>SCORED COUNTS OF INFLUENCERS TO SCIENTIFIC OBSERVATION VIA RELATIONSHIP</td>
<td>48</td>
</tr>
<tr>
<td>FIGURE 7</td>
<td>INFLUENCERS TO SCIENTIFIC JUSTIFICATION VIA RELATIONSHIP</td>
<td>50</td>
</tr>
<tr>
<td>FIGURE 8</td>
<td>SCORED COUNTS OF INFLUENCERS TO SCIENTIFIC JUSTIFICATION VIA RELATIONSHIP</td>
<td>50</td>
</tr>
<tr>
<td>FIGURE 9</td>
<td>GENDER OF INFLUENCERS TO SCIENTIFIC OBSERVATION VIA RELATIONSHIP</td>
<td>52</td>
</tr>
<tr>
<td>FIGURE 10</td>
<td>GENDER OF INFLUENCERS TO SCIENTIFIC JUSTIFICATION VIA RELATIONSHIP</td>
<td>53</td>
</tr>
<tr>
<td>FIGURE 11</td>
<td>RACE/ETHNICITY OF INFLUENCERS TO SCIENTIFIC CRITIQUE VIA RELATIONSHIP</td>
<td>55</td>
</tr>
<tr>
<td>FIGURE 12</td>
<td>RACE/ETHNICITY OF INFLUENCERS TO SCIENTIFIC JUSTIFICATION VIA RELATIONSHIP</td>
<td>56</td>
</tr>
<tr>
<td>FIGURE 13</td>
<td>RACE/ETHNICITY OF INFLUENCERS TO LEGITIMIZING SCIENTIFIC IDEAS/KNOWLEDGE VIA RELATIONSHIP</td>
<td>58</td>
</tr>
</tbody>
</table>
FIGURE 14: GENDER OF INFLUENCERS TO SCIENTIFIC EXPLANATION VIA RELATIONSHIP.................................................................63

FIGURE 15: RACE/ETHNICITY OF INFLUENCERS TO SCIENTIFIC EXPLANATION VIA RELATIONSHIP.............................................64

FIGURE 16: GENDER OF INFLUENCERS TO LEGITIMIZING SCIENTIFIC IDEAS/KNOWLEDGE VIA RELATIONSHIP......................................68

FIGURE 17: RACE/ETHNICITY OF INFLUENCERS TO SCIENTIFIC OBSERVATION VIA RELATIONSHIP..................................................74

FIGURE 18: SOCIOGRAMS WITH WEIGHTED TIES.......................................................81

FIGURE 19: FREQUENCY OF INTERACTIONS VERSUS STRENGTH OF TIES BY RELATIONSHIP.................................................................81

FIGURE 20: FREQUENCY OF INTERACTIONS VERSUS STRENGTH OF TIES BY RACE/ETHNICITY...........................................................82
ACKNOWLEDGEMENTS

My infinite acknowledgements to my loved ones. I profoundly thank my phenomenal spouse, Taina Brown, for helping me through the process of reflecting, writing, and editing this dissertation, as well as making sure that I rest, eat, hydrate, and keep my senses intact. I acknowledge my mother, Janet Cacdac, who is a force to be reckoned with--she ignited my fighting spirit to persist in this arduous academic journey. I am also grateful to my aunt, Jennifer Flanagan, and her wonderful family for always encouraging me through various chapters of my educational career. I respect my grandfather, Julio Cacdac, whose indomitable spirit and larger-than-life personality molded my intellect and emboldened my character as a young explorer. I appreciate the rest of my family for always encouraging me to pursue my goals and ambitions: Joseph Uy, Tito Joey, and all of my relatives (aunts, uncles, cousins, nieces, and nephews) from the Cacdac Family and Yap Family in the Philippines. I also thank our beautiful pets, Foxy and Luna, who always comfort me through this process--we rescued them from the shelter, but soon enough we realized that they rescued us instead.

I also honor my ancestors who have already transitioned: my grandmother Josefina Cacdac and my father Andronico “Boyet” Yap. My grandmother glued the family and brought joy to all of us. My father passed away when he was only 28 years old; I hope I am fulfilling my own version of his interrupted ambition of becoming a chess grandmaster. Finally, I treasure my dear friend, Angel Temple, who passed away during my time at UCLA. She has guided me like a third mother and reminded me to trust my own magic.

My deepest gratitude to my dissertation committee: Louis Gomez, Megan Franke, Cecilia Rios-Aguilar, and Kimberly Tanner. Thank you, Louis, for taking a chance in someone who is
from another field and taking me in as a Bruin. I applaud Megan for the insightful feedback and positive advocacy over the years. I regard Cecilia as an academic aunt who always brings fresh perspectives to the table. I appreciate Kimberly Tanner’s consistent support over the past decade or so, from my undergraduate years to my master’s student years and now through the end of my doctoral years. Collectively, they have made me a better thinker and researcher.

I also thank academic figures who have contributed to my growth at UCLA. Sarah Johnson helped me tremendously in conceptualizing the precursor study that eventually led to this dissertation. She has trained me in my first qualitative study course and provided the space for me to reflect on my own positionality and discernment as a scholar. I am grateful to belong in the Improvement By Design research group, headed by Louis and Kimberley Gomez. In this group, I worked in various capacities with Rebecca Neri and Jahneille Cunningham, who are both friends and scholars that I admire.

I am also grateful for the fellowship support from the UCLA Graduate Division and the Urban Schooling Department in the Graduate School of Education and Information Studies (GSE&IS). I also thank the generous grant from the UCLA Institute of American Cultures (IAC), particularly the UCLA American Indian Studies Center, UCLA Bunche Center for African American Studies, and UCLA Chicano Studies Research Center. Jaime Chan facilitated ordering the gift card incentives and refreshments reimbursements. I also thank the U.S. Department of Education and UCLA Center for Southeast Asian Studies for giving me the Foreign Language and Area Studies (FLAS) Fellowship in my second year as a doctoral student at UCLA.
VITA

~

EDUCATION

2014-2018    Doctoral Candidate in Education
             University of California, Los Angeles (UCLA)
2010-2012    MS, Biological Sciences
             California State University, Los Angeles (CSULA)
2007-2010    BS, Physiology
             San Francisco State University
2005-2006    BA, Black Studies
             San Francisco State University
2004-2005    AA, Liberal Arts
             Diablo Valley College, Pleasant Hill, CA

SELECTED PROFESSIONAL EXPERIENCE

2016        Richard J. Riordan Summer Intern
             Public Policy Institute of California, K-12 Math Misplacement Team
2014-2017   Graduate Student Researcher
             UCLA, Graduate School of Education & Information Studies
2015        Introductory Filipino Language Teaching Assistant
             UCLA, Asian Languages and Culture Department
2013        Environmental Policy Lab Assistant
             Emory University, Department of Environmental Sciences
2012        Teaching/Lab Assistant (Biometry & Intro Biology courses)
             CSULA, Department of Biological Sciences

PUBLICATION

Yap, M.C. (2014). Turning Up For Our Hood and Our Health: How to be an Environmental
Justice Advocate for English Avenue and Vine City. In H. Floyd, S. Goodwin, S. Hill, A.
Vaaler, & M.C. Yap (Eds), Our Community’s Green Future [Curriculum]. Atlanta, GA:
Rollins School of Public Health (Emory University).
Retrieved from ProQuest Dissertations & Theses. (UMI No. 10384).
SELECTED PRESENTATIONS

Sister [Scientist] Outsider: The Influential Social Networks of Women of Color Community College STEM Majors
- Paper: National Women’s Studies Association (NWSA) Meet, Nov. 2018, Atlanta, GA

Sister Scientist Outsider: Social Network Analysis of Women of Color Community College STEM Majors

High-Achieving Women of Color Transfer College Students in the STEM Pipeline

The Potential of Advancing Social Justice in Education via Learning Analytics

From Community College to a STEM Pipeline: Women of Color Transfer College Students in Los Angeles
- Poster: 2017 American Association for the Advancement of Science Annual Meeting (AAAS), Feb. 2017, Boston, MA

Visualizing Community Building and Social Capital in a YPAR Program Using Social Network Analysis

SELECTED HONORS AND AWARDS

FASEB MARC Peer Mentor 2013-Present
UCLA Institute of American Cultures (IAC) Research Grant 2017-2018
UCLA CC2PhD/CCS Graduate Student Mentor 2017-2018
UCLA Graduate Research Mentorship Scholar 2016-2017
Public Policy Institute of California’s Richard J. Riordan Summer Intern 2016
Ford Foundation Fellowship, Honorable Mention 2016
UCLA Graduate Summer Research Mentorship Scholar 2016
U.S. Department of Education Foreign Language and Area Studies Fellowship 2015-2016
Humanities, Arts, Science, and Technology Advanced Collaboratory (HASTAC) 2012-2014
FASEB MARC Grant Writing Seminar and Practical Exercises Workshop Scholar 2013
Summer Institute in Statistics & Modeling in Infectious Diseases (SISMID) Scholar 2013
National Institutes of Health (NIH): MBRS-RISE Graduate Fellowship 2010–2012
EcoHealthNet Summer Research Exchange Scholar (Ecological Epidemiology) 2011
EcoHealthNet Workshop on Mathematical Modeling of Infectious Diseases Scholar 2011
NIH: MARC Program Scholar 2008–2010
CHAPTER I:

Introduction

As a former student in Science, Technology, Engineering, and Mathematics (STEM), I have experienced both positive and negative interactions both on and off campus spaces that have propelled and hindered me in my academic path. On campus spaces include research laboratories, STEM classrooms, and pipeline programs. I gained entry into STEM pipeline programs for people of color that are funded by the National Institutes of Health (NIH) as an undergraduate for two years and as a master’s student for two years as well. I then earned admission to and fellowship offers from four Ph.D. programs in biomedical sciences.

Despite my concrete preparation for a STEM career, I still faced many challenges from my White peers and faculty members in navigating that academic trajectory. For example, I recall being one of only a handful of women of color taking a Computer Science introductory class, so that I could build foundational skills in programming for undertaking my master’s thesis in ecological modeling. When I had a challenging time with writing the correct codes during in-class programming exercises, my professor always expressed his frustration at why I could not figure out what was wrong with my code. When I wrote a coding script that worked, my professor would then falsely accuse me of copying from a classmate. Despite having no evidence for this claim, he harassed me in front of the whole class during. Eventually, I dropped this class because I felt that it was a hostile learning environment. With the help and guidance of my thesis advisor, I still managed to learn enough Matlab coding skills on my own to create simulation models in population dynamics. My advisor also suggested international Biological conferences where I can present my research. He genuinely cared for my well-being both personally and
academically; his support motivated me to finish my master’s program and pursue doctoral studies. However, eventually, these challenges and triumphs—along with an increasingly evolving critical stance on the dearth of diversity in the field—shifted my research career interest into one of advocacy for other women of color in STEM careers.

Statement of the Problem

Despite increasing diversity in the United States and more female students achieving bachelor’s degrees than males, the STEM field remains largely undiversified, with White males making up 60% of the population (Oh & Lewis, 2011). In 2012, the U.S. Census Bureau projected that the United States will have only approximately 40% White residents by the year 2043 (U.S. Census, 2012) —meaning that the country will comprise of a majority of people of color as well as multiracial and multi–ethnic citizens. If STEM professionals lack the knowledge, training, and experience in interacting with the general public that is much more diversified in the near future, then how can STEM leaders and professionals make their work more relevant to the vested interests of the public and the betterment of society as a whole?

Lack of representation of women of color in STEM careers may be attributed to their low retention in their university STEM majors. Underwhelming rates of retention have been blamed on these underrepresented students’ inadequate preparation and training in successfully navigating academia (Koenig, 2009). STEM Ph.D. pipeline programs have successfully increased the numbers of underrepresented minorities in pursuing STEM majors and even graduate work. Yet, even with existence of such pipeline programs, many still do not persist in pursuing STEM degrees and careers (Ong et al., 2011). Community colleges may serve as a primary starting point for academic careers, with 48% of University of California (UC) STEM
bachelor’s degree holders are transfers from community colleges (Community College League of California, 2015).

Recent literature has emerged about the value of diversifying the sciences, including its potential for “harnessing the complete intellectual capital of the nation” (Valentine & Collins, 2015) for solving complex problems (Tanner, 2016), and driving innovation (Page, 2007). However, how does diversity actually manifest in producing knowledge in the sciences? There is a gap in literature about how a diverse background influences a woman of color’s thinking as a scientist, especially how her contextual location as a community college STEM major affects the way she thinks about and performs science.

Purpose of the Study

By investigating the current experiences and insights of women of color community college students, this study aims to explore the influences to the scientific thinking of female STEM students of color at a Hispanic-Serving Institution in Los Angeles. In doing so, I aim to better understand the role such influences may play in the way these students conduct scientific processes, and, hopefully, their future knowledge production in the field.

Research Questions

1) Who influences the scientific thinking of women of color STEM majors in the community college?

2) How do these nominees influence the scientific thinking of women of color STEM majors in the community college?
Significance of the Study

I would like to address the gap in literature on the social relationships that women of color cultivate and the locations they inhabit that affect how they think as scientists in the White-male dominated environment of STEM at the community college level. Although they attend MSIs, the gatekeepers of the STEM field may still promote hegemonic practices that legitimize negative stereotypes about women of color and androcentric views of conducting research. Centering the voices and standpoint of women of color STEM majors that attend community college may illuminate their actual needs and inform pragmatic policies that may support their persistence in the major.

Limitations of the Study

This study only focuses on a sample of 35 women of color in one community college in Los Angeles. Aside from a decent sample size, the number of participants per STEM fields of study (e.g., Biology, Engineering, Astronomy, etc.) are not equal to each other—some are more represented than other majors. Also, since word of mouth was used as a primary recruitment process, the participants may already know each other, so the networks may reflect a specific group of students that belong to certain campus organizations. Yet, since the mode of analysis will create ego-centered networks, this concern will be alleviated, since the focus is on the participant and not the entire network at the study sites.
Chapter I Bibliography


Tanner, K. D. (2016). Diversity, Equity, and Problem-solving: Organizational psychology tells us that if we want to solve the type of complex problems often thrown up by biomedical science, we need diverse teams. The Translational Scientist, 15-16.

U.S. Census Bureau (2012). Name of data or report. Retrieved from [URL]

CHAPTER II:  
Literature

EMPIRICAL REVIEW

*The Double Bind*

Women of color experience multiple challenges based on their gender and racial/ethnic minority status in the STEM field. In 1975, a group of thirty women of color scientists—from diverse cultures and generations—convened to invoke sisterhood in tackling their “common ties” that is now coined as “the double bind”: “those of the double oppression of sex and race or ethnicity plus the third oppression in the chosen career, science” (Malcom et al., 1976). Gender and racial stereotypes are accepted as social norms (Courtenay, 2000), and the gender stereotype is that men are more competent than women, while the racial stereotype is that people of color have inadequate intelligence or skills. A myth that pervades educational corridors is that women of color are just not interested in pursuing the STEM field (Munro, 2009), hence they have low representation in the STEM classrooms and later on, the workforce. However, Ong et al.’s (2011) comprehensive review of 116 studies in the past 40 years dispels this myth by asserting that many women of color enter STEM majors as undergraduates, but face many institutional obstacles and need to negotiate such complex environments that may not be very welcoming toward women of color.

Ong et al. (2011) demonstrated that “underrepresented minority women are just as likely as their White peers to intend to pursue an undergraduate STEM degree” based on a synthesis of at least six empirical studies that occurred between 1987 and 2004. The review revealed the complex “double bind” issues that women of color experience as a minoritized gender and
race/ethnicity in such a White male dominated field. These issues stem from educational equity that affects self-sufficiency and self-conceptions, as well as a toxic climate that affects persistence of women of color in their STEM majors and graduate programs. By addressing systemic problems that create such chilly climates for women of color, their representation levels may improve overall.

Malcom & Malcom (2011) reflect on the new challenges that the current generation of women of color scientists face: gaining support instead of the morality of advancing the cause and the responsibility for action of institutions instead of blaming individuals and accepting biases as natural. This mother-and-daughter scientist tandem recognized the multiple ways of getting into the STEM field instead of the STEM pipeline as merely leaky. This shift has been influenced by the needs of more representation of women of color in STEM. However, more representation has not necessarily translated to STEM program completion and career pursuits.

**Persistence**

Perhaps improving STEM persistence for women of color (or even women in general) starts even before they enter college. When asked to draw what a scientist looks like, even girls as young as fifth and sixth graders drew scientists as males with a lab coat (Barman, 1999). This shows that even at a young age, females view the stereotype of scientists as a male profession.

More and more out-of-school programs try to defy this perception by promoting STEM and recruiting girls at a younger age to the field, such as the Great Science Girls and the Science Mentoring Project. These programs provide opportunities for K-12 girls to engage in scientific activities that may help build their confidence and interest in STEM (Ackerman et al., 2013). Along with having support from parents and role models to emulate, programs that expose girls
to science early in their schooling have been shown to help develop a STEM identity that later on translates to pursuing STEM degrees in college (Buschor et al., 2014). However, these pre-college experiences may not be easily accessible to girls of color, especially those coming from under-funded urban schools in the Los Angeles Unified School District (LAUSD).

Other contributors of STEM persistence occur in the collegial environment itself, such as the increased interactions of women of color at their home institutions. Using hierarchical generalized linear modeling (HGLM), Espinosa (2011) studied the various factors (precollege characteristics, college experiences, and institutional) that may affect the persistence of women of color in STEM majors and compared the results to that of their White peers. The best indicator for STEM persistence for women of color was in the frequency of their interactions with peers, not necessarily professors. Some of these interactions consist of “[discussing]” their class materials, “[joining] STEM-related” campus clubs, “[participating] in undergraduate research programs, and “[having] altruistic ambitions.” It also helped if the student attended a private college and/or an institution “with a robust community of STEM students.” This study provides great quantitative findings on the role of interactions in improving persistence for women of color. However, qualitative approaches should be explored as well to complement these findings. Additionally, not many women of color can afford to matriculate into private institutions.

Community colleges may actually serve as a primary starting point for academic careers, with 48% of University of California (UC) STEM bachelor’s degree holders transferring from community colleges and one-fourth of all Chicano/a doctorate degree holders being transfer students (Community College League of California, 2015). Coupled with STEM diversity pipeline programs, Minority Serving Institutions (MSIs) may provide an alternative “robust community” for women of color attending public universities.
One of the renowned robust STEM communities for undergraduates of color has been established at University of Maryland-Baltimore County (UMBC). Founded as the Meyerhoff Scholars Program, this pipeline program focuses on the strengths of students in color that will help them persist in STEM (Maton & Hrabowski, 2004). In the journey to academic achievement, the program builds on these strengths through “determined and persistent academic engagement,” “strict limit setting and discipline”, “child-focused love, support, communication, and modeling”, “community connectedness” and resources.” This strengths-based approach focuses on building positive causal factors to counter deficit-based factors in order to achieve positive resilient outcomes for students of color (Bowman, 2013). For example, the external factor of “multi-level systemic barriers” becomes replaced with “strong academic and social support system”; meanwhile, the internal factor of “personal deficiencies” is countered by highlighting “personal strengths.” Meyerhoff’s programming has worked well under this model.

However, although the Meyerhoff Scholars Program has impressively been producing numerous STEM Ph.D.-pursuing students of color, it is located in a predominantly White institution with lower numbers of people of color than an MSI. In order to reach more women of color—many of whom attend public institutions, especially MSI’s—such strength-based programs need to be established in MSI’s that serve predominantly students of color in urbanized areas.

Modeled after the Meyerhoff Scholars Program at UMBC, Graham et al. (2013) produced a persistence framework to help retain college students in STEM majors. This focuses on building a student’s agency to increase retention. African-American students in STEM majors switch to non-STEM majors before graduation at a rate of twice as much as their white counterparts. The program also emphasizes building confidence and motivation and guides
students in learning science and self-identifying as scientists through exposing them early to research, promoting active learning, and encouraging students to join learning communities.

Although this model provides examples of different types of participation, it does not provide a rich qualitative account of how the students actually interact with each other outside of the programming that is provided by the program. It focuses on outcomes (whether students earned their degrees or not), but has no information on how students—especially women of color—navigate their STEM majors and campus spaces in their own voices. These pipeline programs create the structure that can increase the participation of women of color in STEM, yet they lack an investigation in centering these students’ voices as they engage (or not) in these interactions. Finally, MSIs, in and of themselves, may not necessarily guarantee a “robust community” for women of color STEM majors without the explicit intention and active participation of its students.

THEORETICAL FRAMEWORK

Feminist standpoint theory (FST)

In feminist standpoint theory (FST), the oppressed social status of women provides them a comprehensive and rich perspective from their marginal location in society; this particular standpoint of reality holds potential in producing knowledge that encompasses dominant points of view. This theory takes into consideration the power dynamics between dominant and oppressed groups while also transforming the struggle of marginalized individuals into an epistemological advantage--a form of self-agency--for observing and analyzing the world at large.

This theoretical framework also transcends mere intellectual inquiry, as it has questioned
scientific objectivity as heavily androcentric (or male-centered)—as the dominant group of scholars in numerous academic disciplines. While science has prided itself in being neutral and apolitical, feminist standpoint theory highly regards social and political liberation as its end goal:

Feminism and the women's movement provide the theory and motivation for inquiry and political struggle that can transform the perspective of women into a "standpoint"—a morally and scientifically preferable grounding for our interpretations and explanations of nature and social life." (Harding, 1986)

A prominent scholar of feminist standpoint theory, Sandra Harding highlights the revolutionary roots and mission of this framework. Rooted in struggle as women in a patriarchal society, feminist standpoint theory anchors itself to the daily existence of women navigating the world under the rules and structures that have been created and enforced primarily by men in power.

Living under these imposed rules and structures, women have accumulated experiences and knowledge—a flexibility and duality as women and as human beings—that provides them a wider angle of seeing and “[interpreting]...nature and social life” (Harding, 1986). This wider angle of experience and interpretation renders marginalized groups with more objective and reliable accounts of truth and knowledge, a notion called strong objectivity (Harding, 2004). As non-members of the dominant gender, women inhabit a unique space or location that is decentered from the mainstream consciousness. Similar to Paolo Freire’s centering of oppressed people’s consciousness as already valuable and potentially liberating (Freire, 1972), feminist standpoint theory recognizes the power of the oppressed and their potential in using their knowledge for freedom and for dismantling patriarchy.

Standpoint versus mere perspective

Feminist standpoint theory values the uniqueness of each individual woman and the
potential for contribution towards a shared knowledge. “When I speak of ‘experience’ I do not use the term as a synonym for ‘perspective,” clarifies sociologist and FST pioneer Dorothy Smith (1974). Standpoint is not merely a point of view, but a full experience in a specific marginalized location that allows an individual (in this case, a woman) to form knowledge that is informed by her experience and is conscious of her dominated location and condition, as though taking a stand against oppression. Standpoint goes beyond the definition of mere perspective, since it implies a political epistemological stance--consciously standing up for one’s human right against oppression. Smith (1974) continues:

Our knowledge of the world is given to us in the modes in which we enter into relations with the object of knowledge.

Smith reflects on how experience-informed knowledge--which is essentially wisdom--shapes how we “enter into relations” or engage with what we are studying. This wisdom weaves into ways of interpreting and making sense of the “object” being analyzed. Harding (2004) calls this rich experience translated into a more accurate worldview, termed as strong objectivity.

Nonetheless, although it values women as potential contributors of knowledge, feminist standpoint theory does not simply assume that all women would have a monolithic experience that could work towards dismantling the patriarchy. Jaggar (1996) points out how womanhood cannot be the sole criterion of having a standpoint:

Simply to be a woman, then, is not sufficient to guarantee a closer understanding of the world as it appears from the standpoint of women….While women’s experience of subordination puts them in a uniquely advantageous position for reinterpreting reality, it also imposes on them certain psychological difficulties, which must themselves be the focus of self-conscious struggle....Simply to be a woman, then, is not sufficient to guarantee a closer understanding of the world as it appears from the standpoint of women.
Since women still operate within systems of oppression, they have been socialized into the norms of androcentricity—the centering of male interest and cultivating of male privilege (Harding, 1991). Women have undergone “psychological difficulties” from their “subordination”—a trauma that they must overcome, sometimes as the “focus of self-conscious struggle.” This struggle for survival could become so overpowering, time-consuming, and energy-draining that living through it may leave less energy and time for reflection and, hence, “a closer understanding of the world.” The capacity to survive this said struggle and also question the hegemonic practices that have been set up within society’s systems of oppressions transforms a woman’s mere perspective into a standpoint that carries a wider angle of analysis than an individual living under privilege within the system.

Hartsock (1983) distinguishes feminist standpoint theory not merely as exposing positive and negative dimensions of women’s experience as an oppressed group, but also as a concept of transformation. According to her, “a feminist standpoint picks out and amplifies the liberatory possibilities contained in that experience.” Being a woman does not grant default standpoint status, but it can enhance an individual’s experience and provide the grounds for growth of specific knowledge that may be necessary for dismantling various systems of oppressions.

In this study, the women of color community college student participants will be interviewed regarding the influences to their scientific thinking. Aside from being women of color, they have a specific unique history of attending community colleges that are MSIs. Their standpoint may differ from other women of color, traditional college students, and students attending primarily White institutions. All of these factors further intersect with each participant’s specific socio-economic, family, and immigrant backgrounds, producing a potentially complex and interwoven shared story about these women.
Location

Women’s unique standpoint comes from living in the margins of society. They occupy a specific location away from the androcentric majority that lives at the core of socio-political life with the rules emanating from their focal position a la epicenter--literally the frame of reference for the underworking of the system. Smith (1974) describes the complexity of women’s location within society:

Women are outside and subservient to this structure. They have a very specific relation to it which anchors them into the local and particular phase of the bifurcated world….The only way of knowing a socially constructed world is knowing it from within. We can never stand outside it.

Smith contends the irony of being “within” the system and yet being “outside and subservient to this structure.” Women “can never stand outside” of the systems of oppression, because they live in it—and, unfortunately, “can never stand outside it”. Women traverse the system every day under its hegemonic and legal rules and regulations. Yet, they are also outsiders within the system, since they have to negotiate their marginalized status--play the game per se--to survive and, hopefully, thrive. Women’s status “anchors them into the local and particular” part of the system, to a specific location in the system.

Black Feminist Epistemology (BFE)

Pioneering scholars of Black Feminist Epistemology further developed the concept of social location in conceptualizing the Black feminist standpoint. Grounded in the experience of racism from liberal White feminists, Black feminist scholars asserted a unique standpoint for Black women that appropriately represented their experience based on the intersections of their race, gender, socioeconomic status, sexuality, etc. Prominent works by bell hooks, Kimberlé Crenshaw, and Patricia Hill-Collins have advanced BFE theories with complex ruminations on
location-specific standpoint. For example, hooks (1984) acknowledges “living on the edge” since her childhood—even entitling her book “From Margin to Center” to challenge the ignored voices of Black women in feminist scholarly circles:

Living as we did--on the edge--we developed a particular way of seeing reality. We looked both from the outside and in from the inside out.

In this passage, hooks speaks of the insider/outsider experience which FST has touched upon, but now applies it to her specific experience as a Black woman. Her racial identity compounds the gender domination, although not necessarily in a separate manner--all interactive dimensions of herself simultaneously criss-crossing and affecting her experience all at once, creating multiple tangents of oppression merged in a single coordinate “on the edge.” Collins (1986) affirms this unique standpoint:

“Outsider within” status has provided a special standpoint on self, family, and society for Afro-American women.

She confirms that this “special standpoint” influences how Black women view themselves, their families, and society at large. This also implies that these three units of analysis (“self, family, and society”) form the socio-ecological systems that Black women navigate on the individual, micro/mesocosm, and macrocosm levels, which may also serve as sites of knowledge production.

Collins also adopts the term “intersectionality” from Crenshaw (1991), who first coined the term to advocate for a new discourse for making sense of the interactive oppressions (of race and gender, etc.) that Black women experience. Rooted in BFE, intersectionality seeks to “[understand how multiple social identities such as race, gender, sexual orientation, socioeconomic status, and disability intersect at the micro level of individual experience to reflect interlocking systems of privilege and oppression (i.e., racism, sexism, heterosexism,
classism) at the macro social structural level” (Bowleg, 2012; Crenshaw, 1995; Collins, 1991). In this study, the complexity of layered institutions--of schools, of financial resources, of social welfare services, etc.--simultaneously affect the struggles of women of color community college and transfer students.

Collins elevates BFE’s (and FST’s simultaneously) location-specific standpoint by theorizing on the Matrix of Domination (MOD), which represents the overall organization of power in a society. To challenge systems of oppression, one should consider the reality of individuals navigating a MOD, a historically and socially specific arrangement of “intersecting systems of oppression” (Collins, 1990) according to these interrelated domains: structural, disciplinary, hegemonic, and interpersonal. The structural domain refers to social structures in place, such as schools; in this study, this domain would be equivalent to STEM institutions. Meanwhile, the disciplinary domain comprises of the bureaucratic organizations that manage oppression; in this study, this domain would apply to STEM professors and teachers, department chairs, and other college administrators. The hegemonic domain covers the ideology and consciousness that legitimizes oppression; in this study, this domain consists of stereotypes about women of color, community college students, and transfer students. Finally, the interpersonal domain involves personal relationships that influence daily life; in this study, this domain includes classmates, labmates, student organization participants, family, and friends.

Although “women’s oppression is constantly changing in forms and these forms cannot be ranked” (Jaggar, 1983), solidarity at these various domains can still benefit the cause. Jaggar (1983) advocates for full inclusion of women of color to feminist studies: “A representation of reality from the standpoint of women must draw on all women’s experience.” When all women collectively share their knowledge from their unique standpoint, reality is better interpreted and
knowledge is more accurate.

**Hegemonic knowledge production**

In addressing the field of sociology, Smith (1974) discusses how the field takes on the viewpoint of its gatekeepers and practitioners, setting the status quo of the field according to their own experience, despite attempts of maintaining objectivity as social scientists. With White men dominating the field, their perspective becomes the default in numerous dimensions of the institution—especially in how knowledge is produced, taught, and even shifted.

The first difficulty is how sociology is thought--its methods, conceptual schemes, and theories--has been based on and built up within the male social universe (even when women have participated in its doing). It has taken for granted not just that scheme of relevances as an itemized inventory of issues or subject matters...but the fundamental social and political structures under which these become relevant and are ordered.

Since the theoretical frameworks available all assume the hegemonic perspective of the White male, women may lack the tools to even articulate their own experiences without referencing it to the male-centric status quo. Even as women “participated” in the field, they still ascribe to the concepts and tools that have been produced over generations primarily by men. The whole infrastructure of the field has been built over time with the direction of White male scholars, thereby influencing the field’s internal mechanisms, scholarly protocols, and ideals. The hegemonic perspective has been embedded into every fiber of the institution. Furthermore, Smith continues:

[The sociologist] moves among the doings organizations, government processes, bureaucracies, etc., as a person who is at home in that medium. The nature of that world itself, how it is known to him and the conditions of its existence or his relation to it are not called into question.
This hegemonic point of view of the dominant demographic (White male) scholar permeates his ways of knowing and being within this institution. He navigates familiar territory since the system has been built and adapted to his identity in thought and practice. As though a machine set to default settings of his choosing, he navigates this structure with less resistance and more comfort than any other underrepresented demographic that is not “at home in [this] medium.” This privilege enables the dominant group members to thrive in this system and continue perpetuating this self-serving cycle as though oiling the machine, upholding the status quo. Similarly, as in another White male-dominated field such as STEM, the White male perspective has shaped the field and vice versa.

*Implications for Women of Color in the STEM fields*

Women of color students’ locations affect their knowledge production. Since it characterizes “relations between the production of knowledge and practices of power” (Harding, 2004), feminist standpoint theory holds promise in magnifying the experience, power struggle, and knowledge production of women of color pursuing STEM majors and careers. FST counters hegemonic practices that have been set by the majority in STEM fields; it offers an alternative account and conceptualization of seeking truths about the natural world--from the marginal locations of women, especially women of color. Oppressed groups such as women of color have lived through this marginalized condition and developed an “oppositional consciousness” (Collins, 1989; Sandoval, 2004) that can be used to negotiate, resist, and possibly even overthrow a whole system. Women of color’s locations afforded them to develop this oppositional consciousness that can empower them to successfully navigate any system of domination and even liberate themselves. FST highlights how women of color STEM students
can turn their own challenges into sources of knowledge and empowerment.

Unfortunately, for those who may be first-generation college students, such as many women of color community college students, the limited experience and knowledge of navigating higher education (and the educational system in general) may cause self-doubt in one’s academic and career choices. Hence, the unfamiliarity of a surrounding such as a community college could lead such students to model their academic behavior and decisions according to their professors and mentors that have obviously advanced in the academic arena. Driven to succeeding in STEM, perhaps these students follow the footsteps of individuals that they perceive to be experts. In order to gain career traction, it seems natural to engage in practices that the professionals in the field approve and encourage. However, since women of color do not belong to the majority in STEM, they may be replicating hegemonic practices that have been set up by the majority to keep the dominant in power. Because women of color still get training and generate knowledge the same way that it has always been done, it is possible that they only continue upholding the status quo instead of generating critical and diverse ideas.

Members of oppressed groups may suppress their own original ideas and voice, especially if these misalign with the appropriate values and vested interests of the gatekeepers of the STEM field. Although it may seem as a form of self-bargaining to advance one’s career, negotiating one’s opinions and creativity may stifle the unique possibilities of producing actual innovative ideas. With growing calls for diversity in the STEM field to intellectually advance the field (Page, 2007; Tanner, 2016; Valentine & Collins, 2015), distinguishing between diverse bodies and ideas may become critical in truly diversifying the field. Putting value in women of color’s own unique voices and standpoint may foster independent thinking and encourage leadership. Thereafter, aside from having more intellectual flexibility in cultivating diversity in
thought, women of color who attain leadership opportunities become career gatekeepers and enforce a fresh culture and climate of highly regarding inclusion and diversity of both bodies and thoughts.

**Critical Social Network Analysis**

*Social Network Analysis (SNA)*

Social network analysis (SNA) is the methodological tool for this study in exploring how the concept of (marginal) location may influence an individual’s standpoint, and hence, knowledge production. SNA is an analytical tool that can be used for studying the social structure of a network (Otte & Rousseau, 2002). Interest in whole social structures includes learning about membership in a social network that may lead to gaining social capital or “aggregate of actual or potential” benefits or resources (Bourdieu, 1985). On the other hand, an individual’s personal network or ego-centered network can also be magnified: in this type of network, the focus is on a specific individual or ego and her social ties or connections to other individuals called alters (Newman, 2003). In alignment with the social resources theory, looking at the attributes of the alters may shine light on an individual (ego)’s access to resources and information (Lin et al., 1981).

The key factor of locationality in a social structure drives many researchers towards SNA, especially when spatial factors are considered. Borgatti & Ofem (2010) describe a 1930’s seminal work in modern SNA:

...the work of Jacob Moreno....noticed that runaways at a school for girls tended to occur in clumps. He argued that the social links between the girls served as channels for the flow of ideas. In a way that even the girls themselves may not have been conscious of, it was their location in the social network that determined whether and when they ran away.
The location of these runaway girls’ social connections affected the diffusion of the idea and execution of running away from their school. Perhaps the girls who harbored the same idea and motive collaborated in their clique with the shared goal of escaping. This concept of diffusion of ideas and influence continues to spark interest among social network scholars today.

**Critical SNA**

SNA scholars utilize heavily quantitative ways to calculate measures that try to capture diffusion of ideas and influence in networks, such as regression analysis. Granovetter’s (1973) classic paper on the strength of weak ties employed the linear regression models in using indicators to make predictions about how strong a social tie is between two individuals or nodes. The indicators that he used included amount of time, emotional intensity, intimacy (mutual confiding), and reciprocal services; after predicting the strength of tie, Granovetter found that weak ties (relationships with acquaintances instead of closer relations with friends or relatives) became more frequent sources of job referrals. For the purposes of this dissertation, measuring ties in this manner may not seem applicable to the study since it does not concern the diffusion of job announcements through a social network; diffusion of influence may be more complex since it may require some trust for an individual to become influenced by another individual. In addition, inferring mutual confiding or intimacy would be difficult due to uneven age, generation, and power dynamics between the participant and her nominee.

Similarly, Marsden & Campbell (1984) calculated tie strength of friendship data based on the predictions of these indicators: closeness, duration, frequency, breadth of discussion and mutuality. In terms of applicability to this study, the length or duration of knowing an individual does not necessarily capture the relationship of the participant or when they developed their
emotional intensity. Topics discussed between individuals could also vary, yet their relevance to scientific thinking may be questionable. Finally, again, mutuality would be challenging to infer, especially since the probability of an elder nominee (who may be a professor, for example) to nominate back a student as an influencer to her scientific thinking may be slim; besides, only the students can participate and nominate, so there would be no way to verify the mutuality of nomination of influence to one’s scientific thinking. Finally, like Granovetter, Marsden & Campbell’s study neither occurred in education settings nor involved students, most especially not women of color STEM majors in a community college; hence, using their calculations of tie strength as predictors of influence seems irrelevant.

With the use of sophisticated quantitative methods such as multilevel regression models and SNA, Rios-Aguilar (2014) encourages scholars to “start reimagining and reinventing critical quantitative inquiry” towards “research in higher education that is rigorous, relevant, meaningful, and critical.” With the use of sophisticated quantitative methods such as multilevel regression models and SNA, Rios-Aguilar (2014) encourages scholars to “start reimagining and reinventing critical quantitative inquiry” towards “research in higher education that is rigorous, relevant, meaningful, and critical.” Researchers ought to not blindly follow methodological trends without the consideration of the reality of the context--if it actually applies to the research situation or if it perpetuates deficit frameworks and stereotypes about already marginalized students. With more available high technology and methods come great responsibility.

Influential Networks

Faculty members can impact how students conduct research, and, hence, the production of scientific knowledge. Leahey (2006) shows the influence of research advisors on their
advisees in all aspects of research. The scopes of this influence may include narrowing research focus, brainstorming hypotheses, recommending specific articles or scholars, designing methods for data collection, choosing appropriate analysis for establishing statistical significance, dealing with unexpected data and results, etc. Practically, the faculty member becomes heavily involved in the entire research practice of the student. This is standard practice in biomedical lab settings, where oftentimes students “latch on” to already existing projects with funding, including lab materials and high-tech machines ready to be used at their disposal. Essentially, research faculty members play a major role in research, and, hence, the production of knowledge in science. If they mentor women of color and other underrepresented groups, those professors transfer their skills, practices, and ideology to the next generation of scientists.

Peers and relatives may also influence the development of scientific thinking of students. Espinosa (2011) attributed frequent interactions with peers on-campus form a “robust community” that may contribute more to women of color STEM students’ persistence than interactions with their professors. Parents with technical backgrounds in engineering and computer science have also been shown to cultivate the interest in STEM of middle school pupils (Barron et al., 2009). However, neither study focused on the experiences of women of color that attend community college.

Summary of Theoretical Framework

This study draws on feminist standpoint theory and network theory in making sense of how social networks may affect women of color STEM students’ scientific thinking. In feminist standpoint theory, the oppressed social status of women provides them a rich perspective from their marginal location in society, holding potential in producing knowledge that transforms their
struggle into an epistemological advantage—a form of self-agency. Women of color students’ locations affect their knowledge production. Since women of color do not belong to the dominant group in STEM, they may just be replicating hegemonic practices that have been set up by the dominant group to keep the dominant in power. Because women of color still get training and generate knowledge the same way that it has always been done, it is possible that they only continue upholding the status quo instead of generating critical and diverse ideas. In complex systems theory, location-specific localized interactions (e.g., neighborhood effects) can affect community structure. Studying the social networks of women of color community college STEM students in MSIs may show how their social locations may affect their thinking as scientists.
Chapter II Bibliography


Tanner, K. D. (2016). Diversity, Equity, and Problem-solving: Organizational psychology tells us that if we want to solve the type of complex problems often thrown up by biomedical science, we need diverse teams. *The Translational Scientist*, 15-16.

CHAPTER III: 
Methods

Researcher Positionality

My personal experience informed my positionality regarding this research topic. As a former STEM student, I have inhabited similar spaces as the students who I will study. I have both very positive and negative experiences that I hoped not to project onto my participants and study. Based on my positionality, I wrote reflective memos about my assumptions to avoid projecting these assumptions onto my participants. I am both an insider and outsider in the study site.

I am an insider because I have become a staff member in the site, I have been a community college student in the past, and I am also a woman of color with STEM degrees. While performing routine staff duties on-site, a student told me that a random strange young man has been following her since she parked her car blocks away in the parking lot. I helped her escape this stalker by giving her access to a staff-restricted area while distracting the strange man by asking if he needed help with anything. After this incident, the student ended up becoming one of the participants featured in this study. Additionally, having navigated community college campuses (even after transferring to a four-year institution) also allowed me to walk in the participants’ shoes as I stroll through similar halls and pathways on the site. Finally, being a former STEM scholar has given me perspective on taking STEM courses that they may be taking. For example, while recruiting a potential participant, she shared her current struggles in her Microbiology class. In that moment, I halted the recruitment process and proceeded to help her figure out which biochemical tests to perform to identify an unknown bacterial species for her final project. I benefited from being an insider, since the participants are familiar with me
and they may feel comfortable sharing their experiences. However, being a staff member who interact quite frequently with some of the STEM professors in a different professional capacity may affect my (positive and negative) views about these few faculty members that participants may have nominated. For the study, I based the findings on what the students shared about these professors instead of projecting my own opinions about them.

On the other hand, I am also an outsider, because I am not currently a student at the site navigating the campus spaces. Although it is possible that I may have navigated the same exact spaces that they now inhabit, I view these spaces from a different perspective now and in a different functionality as the participants. The people that I encountered before may not be the same as the ones that they encounter now. The benefit of being an outsider is that I did not take the place and events happening there for granted.

**Accessibility**

Considered a staff member, I am also a regular face at MCC, helping prepare laboratory materials for classes and facilitating skills-building workshop for the Life Sciences Department and a campus organization for STEM students of color. In Fall 2016, I led a series of workshops on crafting the Personal Statement for STEM students who were applying for transfer to four-year colleges; attendees also signed up for one-on-one sessions for detailed feedback on their drafts. In Winter 2017, I started attending the regular meetings for the campus organization and facilitated a workshop on how to build the students’ STEM-focused resumes. I also offered to schedule one-on-one meetings for detailed feedback on their resumes. I also attend faculty/staff meetings and interacted with STEM faculty regularly.

My STEM community involvement at MCC has connected me with participants and their acquaintances via word of mouth. Additionally, I also sent out a confidential survey to students
taking STEM classes (via online and print) and identified potentially interested participants who provided their email addresses if they were interested in participating in a study on social study habits and behaviors. Some professors and students have helped me in obtaining survey participants. I also spoke to students one-on-one in study rooms and classroom halls as they waited for classes and labs to begin.

Since I was already acquainted with faculty members, college staff, and a small number of students, I gathered interest by contacting students who I had interacted with professionally via workshops. I also asked these first contacts if they could refer other women of color into my study. The rationale behind connecting with previous student contacts is that they may provide candid statements since they are more familiar with me even as an acquaintance. Our close connection may affect how I ask them questions, since I have previous knowledge on how to best communicate with them. I am aware of these potential biases with obtaining and handling data related to acquainted participants. To minimize such biases, I tried to adhere my interview questions to the research questions of interest. On the other hand, the rationale behind asking the first contacts to refer fellow participants is that it may also encourage these participants at one degree of separation to also become candid in their in-depth interviews. The downside of this referral system is that since these students may be acquainted with one another, they may be similar to each other based on association. However, their familiarity with each other may enhance the chemistry during the focus group session of this study, which will be discussed in more detail later in this section.
Internal Review Board (IRB) Approval

This study has already been approved by UCLA’s North General Internal Review Board (IRB) on February 1, 2016. Its case number is IRB# 16-000078. The IRB approval expires on January 31, 2019.

Site and Participants

A two-year MSI in Los Angeles, Marvel Community College (MCC) is also considered a commuter school and a Hispanic-serving institution (HSI) with approximately 50% Latino student body and almost 50% first-generation college students in Fall 2015. To preserve its anonymity, I cannot add a citation to the source of these statistics, although the source can be described as an “Annual College Profile” handout that is posted in MCC’s website.

Participants

35 women of color STEM majors participated in this study. In terms of racial/ethnic background, the participants comprise of eighteen Latina, six Black/African American, six Asian Pacific Islander, and five Multicultural students. In terms of fields of study, participants are pursuing the following fields: fifteen in Biology, eight in Chemistry/Biochemistry, two in Physics/Astronomy, six in Engineering, three in Nutritional Sciences, and one in Computer Science. 21 of the participants are first-time college students, nine have previously or are concurrently attending a four-year college, and five have finished a non-STEM college degree in the past. Most of the nine participants who have previously attended a four-year college gained admission to the four-year institution, attended for a year or less, then withdrew for various reasons, including academic and traumatic experiences. Examples of non-STEM degrees include Fashion Merchandising and Sociology.
Establishing Participant Eligibility

I established eligibility for participation based on the following prerequisites: (1) self-identified woman of color, (2) a community college student, (3) a current STEM major, and (4) pursuing a STEM major upon transferring to a four-year institution. Identification as being a woman of color occurs as a self-identification with full or partial membership in a community of color (not White). Since I use the term “woman of color” frequently in my academic, professional, and personal circles, I have semi-consciously assumed that its definition is common knowledge: a woman who is Black/African American, Chicana/Latina, Native American, Asian/Pacific Islander, or mixed race/culture. However, after one of the workshops that I facilitated at MCC, a student insisted that she would not be eligible for the study since she was not a woman of color. Her friend asked if she was eligible and I said if you are “Black/African American, Latina…” Then, the friend said to the student, “Oh, you’re Latina, you can do it, too!” Afterwards, the student gave me her contact info, in order to be a part of the study.

There is also another participant who immigrated from the Caribbean in her youth, and she expressed that having to declare her racial/ethnic identity reminds people that they are deficient when they are not White. She also did not want to identify as anything but human, but I said that for the purposes of the study, I need her to declare something to determine her eligibility according to the oral consent form that I submitted to the UCLA IRB. Otherwise, all other preliminary participants did not have philosophical issues surrounding their identity as being labeled as women of color.

At first, I also wanted to recruit participants who have never gone to a four-year school before; however, I have met some students who have gone to four-year schools but are in the community college for various reasons. For one, the student may have first attended a four-year
school straight out of high school, but had to leave due to extenuating circumstances, such as
taking care of a sick family member who lives nearby, withdrawing because of academic
hardship, struggling to afford paying for school, etc.

In addition, a student may have obtained a degree in another field, but would like to
pursue STEM now. Since I am interested in those who would like to study STEM, enforcing a
rigid restriction on whether the student has attended a four-year institution before seemed
irrelevant. It is possible that a student who is in this predicament would have a larger social
network (from friends and connections that they have made in the four-year school); but, since
she was in another field of study in this scenario, this student may not necessarily have friends in
the STEM field. It is possible that they barely took any science, math, technology, or
Engineering classes, where they would have been exposed to STEM majors. Since this study
focuses on social interactions and networks, this potential bias has to be explored for such
exceptional cases. Nonetheless, so far, most, if not all, participants had no previous bachelor’s
degrees.

The requirement for being current STEM majors is important, although it also can be
limiting. It can be limiting for community college students who may not declare this major
officially, yet they have interest in STEM-related matters but not enough knowledge about
switching their majors or even higher education opportunities in general. One of my preliminary
participants was previously a Nursing major who only switched to Biology in order to join a
campus STEM program at her community college so that it can fund her ambition to go to a
national STEM conference with her friends. The concern here is that many community college
students are exploratory about their academic trajectory, so there may be more potential STEM
majors out there than those who have declared the major. However, the value of having already
declared STEM majors is that these students have probably taken enough STEM courses to come
to the decision of making it official; this also means that they have engaged in performing
scientific tasks and experienced possible moments of reflection on what it means to be a
scientist--which would allow them to form perceptions of themselves as scientists, one of the
foci of this study. Finally, focusing on official STEM majors also decreases variability among
the participants, in terms of making sure that all of the participants actually want to pursue these
fields. Since I hope to find commonalities and differences among all the participants and
eventually publish on such findings, it was crucial to make sure that all participants had a solid
interest in STEM fields, whether or not they actually finish these majors after they transfer.

Some of the participants have already transferred to four-year institutions in Fall 2017,
while others are still in the beginning of the process of applying to transfer. This reminded me of
the fact that the students were at different stages of their community college career. Some had
been around the community college longer than other participants. For the study, this means that
the participants who had been around the campus longer had more time and opportunity to
expand their social networks. It also means that they could have taken more classes that are
required to transfer as STEM majors, which means that they more opportunities to develop their
self-perceptions about being scientists.

**Participant Screening and Oral Consent**

I asked the following screening questions:

1. Do you identify as a woman of color?
2. Are you current community college student?
3. What is your major?
(4) What major are you pursuing when you transfer to a four-year institution?

If the student gave the following answers to the questions above, then she would be considered eligible for the study:

(1) Yes (Affirmative on being a woman of color)
(2) Yes (Affirmative on being a community college student)
(3) STEM-related major, such as Life Sciences/Biology, Chemistry, Physics, Engineering, Technology, etc.
(4) STEM-related major, such as Life Sciences/Biology, Chemistry, Physics, Engineering, Technology, etc.

**Mixed Methods: Qualitative Social Network Analysis**

*Qualitative Study*

According to Rockwell (1991), “the ethnographer attempts to grasp the ‘local knowledge’ of the phenomenon being studied and integrate it into the description.” I aimed to conduct this qualitative portion of the study to get ahold of this “local knowledge” of the phenomenon of being women of color in a STEM pipeline program. To obtain this localized knowledge, I elicited any stories about the nominees that participants named as influencers to their scientific thinking and gained more local knowledge of participants’ environments. All participants in all aspects of the study were also anonymized. I have respected the confidentiality of all the participants. Any student had the option to leave-at-will if they wished to terminate participation at any time during the study or after data collection and prior to any potential publication of the findings.
Social Network Analysis (SNA)

SNA is performed in two parts: (1) deriving social interactions from interviews and (2) co-creating sociograms of ego-centered networks with participant. I used R’s sna package to create the sociograms. Tableau was also utilized for visualizing data. Relational and attribute data of the alters were also collected in Part II of the SNA.

Part I of the Social Network Analysis involved a name-generator portion, in which participants name influencers to five different aspects of their scientific thinking, if applicable. Once a nomination has been named, demographic information of the nominee was also recorded, including the categorical relationship with the participant. An example of a family nomination would be a participant talking about her mother supporting her endeavors since she was in elementary school. In this particular case, a social tie was drawn between the participant (the ego) and her mother (an alter) for the participant’s ego-centered network. Such social ties between nodes can also be weighted based on frequency of nomination during the interview and frequency of interactions with the mother. It is also possible that the participant’s mother has been a negative force in the student’s life. In this case, a social tie can still be drawn between them, except this would be considered a negative nomination. Hence, a minus would be added to the social tie between the two nodes.

Part II of the SNA comprises of creating ego-centered sociograms to highlight the influences to a participant’s her scientific thinking and their relationships in her personal and professional development. I used open-source network tools (R packages sna, igraph, and network) to map out ego-centered networks and analyze them. I also used the software Tableau to create graphs and facilitate finding trends in the nominations.
I interviewed the participants regarding the influencers that have shaped their identities as scientists. During this interview, I asked the participant to elaborate on the individuals that they nominated and their rationale for the nomination. I also allowed the participants to list individuals who may have influenced them, but in negative ways. It is possible that these memorable negative interactions might still have shaped their aspirations, for better or worse. Any negative influences would just be accounted for by using a negative nomination (minus), as opposed to a positive nomination (plus). Here is a list of specific questions that were asked to capture various aspects of scientific thinking:

Specific Questions on Who Influenced Specific Aspects of Scientific Thinking

- Scientific Observation: Can you think of individuals that have influenced the way you make scientific observations: the way you look at problems or use tools to collect data?
- Scientific Explanation: Can you think of individuals that have influenced the way you explain scientific concepts or arguments?
- Review & Critique Scientific Knowledge: Can you think of individuals who have influenced the way you interpret evidence or analyze knowledge?
- Justification: Can you think of individuals who have influenced the way you justify knowledge or take a position and assert it?
- Legitimizing Science Ideas/Knowledge: Can you think of individuals who have influenced the way you legitimize science ideas or knowledge, i.e., favoring evidence-based methods over other ways of thinking?
Since the goal of standpoint is to center the lived experience of the participant, the ego-centered network fits this goal methodically. The central node is the ego; as applied to my study, the ego is the participant. The lines connecting the nodes to each other are the social ties between those nodes. Since this is an ego-centered network, all non-ego nodes called alters have a social tie with the ego (otherwise, they would not appear in her social network). The different linear thickness of the social ties represents the strength of tie, which is calculated in this study by how many times the nominee has been nominated in different aspects of scientific thinking. Sometimes, those alters connect with other alters as well, if they share an affiliation. For example, all of the orange alters connect with each other because they are the ego’s neighbors, as indicated by the orange color of the nodes. The other node colors in Figure II also represent the relationship with the ego. Additionally, if participants knew each other, it was possible that they (and their alters) showed up on each other’s sociograms. This can create a whole system of small worlds or ego-centered networks that may have some connections to each other.

In terms of network measures, each ego-centered network can be analyzed as its own entity in terms of its shape, structure, and composition, as well as in relation to other ego-centered networks. With both relational (social ties from ego to alters and alters to alters) and attribute (age, gender, race/ethnicity, education level, affiliation, profession, etc.) data, networks can be analyzed for degree centrality (how many nominations for influencer of specific aspect of scientific thinking), strength of ties (how often a nominee was nominated for all aspects of scientific thinking), and homophily (how similar nodes are to each other based on attributes).

Since I am interested in social interactions, I also asked the frequency of interactions between the participant and nominee. During the interview, the participant was asked to quantify
the frequency of interactions (“How often do you interact with this individual?”) by choosing one of the following options:

1. = years at a time
2. = once a year
3. = once every six months
4. = once every month
5. = once every week
6. = every day

In summary, here is the list of data that were collected for constructing the ego-centered network using R:

- Attributes of the ego
- Name nominations = obtain a list of alters
- Name interpreters = obtain relationships of the ego to the alters
- Alter Attributes = obtain attributes of the alters

**Analysis**

Social network analysis consisted of ego-centered networks, focusing on the qualities of the ego- alter relationships and tie strength.

**Validity Threats**

A concern for this study is that I am focusing only on students who have declared a STEM major. How about students who learn later that they would like to declare a STEM major? How about students who decide later that they want to leave a STEM major? However, my
research study just offers a snapshot of a year when these particular students declared this major and intended major upon transferring. Also, some may raise concerns about representing men of color or White women in general since they are also underrepresented groups in STEM. For this particular study, I was not able to address their exclusive issues as of now. Perhaps, I can emphasize their experiences as well in future studies.

My reflective memos before data collection and after data analysis helped me curb down my potential biases and assumptions based on my insider-outsider status. I also member-checked with the participants to check accuracy of my interpretation of the interviews and observations that I gathered.

**Timeline for Completion**

*Completing Data Collection*

Social network data was collected between March 2017 and March 2018.
Chapter 4
Results

This section presents the findings regarding the influences on the scientific thinking of all 35 participants. Figure R shows all of the questions that correspond to specific aspects of scientific thinking. The first question inquired about scientific observation: the way one examines something in detail. Then, the second question asked about scientific explanation: the way one explains ideas or arguments. The third question then inquired about scientific critique: the way one interprets evidence and critiques arguments. Afterwards, the fourth question solicited influences on a participant’s scientific justification: the way one takes a position and defends it. Finally, the last question was related to legitimization of scientific knowledge: the way one values logical and rational thinking.

Figure 1. Questions Asked Regarding Scientific Thinking.
When a participant named an influence to her scientific thinking (by answering any of the five questions), this is called a nomination. Participants did not have to nominate anyone in answer to any of the questions, but if they did, these nominations and their demographic information (if applicable) have been recorded. Most of the nominations were people, so sometimes this section refers to nominations as “nominees” as well. When nominations were non-human entities, such as a television channel like PBS or abstract entities like God, they received null gender and null race/ethnicity designations in their recorded demographic information.

All 450 nominations have also been categorized according to their relationship to the participants (“categorical relationship”). Family (“fam” in the codebook and subsequent diagrams in this section) comprises of mothers, fathers, grandparents, siblings, uncles, aunts, cousins, and other relatives. College faculty and staff (“cc”) make up of professors, college campus staff (who are not students), and off-campus program coordinators that belong to organizations that expose community college students to off-campus internships and other career opportunities. K-12 educators and staff (“k12”) come from a participant’s elementary, middle, or high school. Public figures (“pf”) represent individuals or entities who are well-known in their field or local community servants in the public eye; this category also includes fictional characters or media outlets that a participant follows. Peers have been divided into Schoolmates (“sm”) and Friends (“fri”). Schoolmates can be friends met in college or student acquaintances (such as academic tutors) on campus. Meanwhile, the friends category encompasses childhood friends, non-married significant other, and other friends who did not meet the participants on campus. Local community members (“loc”) inhabit the same communities as the participant, but are not necessarily friends; examples may include church members, off-campus work
supervisors, or a previous significant other. Lastly, religion ("rel") represent nominations from religious texts, such as God, Jesus, and Buddha.

The overall scientific thinking results have been compiled from five specific elements of scientific thinking: observation, explanation, critique, justification, and legitimization of scientific thinking or rationality. When analyzed individually, each process of scientific thinking renders some variability in comparison to the aggregated analysis of scientific thinking umbrella. Data have also been disaggregated by categorical relationships, and further via gender and race/ethnicity.

Figure 2. Categorical Relationships of Influencers to Scientific Thinking
Summary of Results

Family had the largest number of nominations in all aspects of scientific thinking. Figure 2 captures the total number of nominations for who influences all aspects of scientific thinking as represented by specific bubble color for relationship type to participant and by bubble size for number of times nominated for all aspects of scientific thinking. Out of all 450 nominees, relatives received 150 nominations, corresponding to approximately 33%. Since none of the participants were related to each other, this means that each family nomination was unique to every participant—with each family nominee having a range of being nominated from once up to five times maximum. This also means that the number of unique relative nominees ranged from 30-150. Hence, the family category also contained the highest number of unique nominees among all categorical relationships.

To account for participants who nominated substantially more individuals than other participants, a “scored” count has been performed by restricting every participant to one maximum nomination per categorical relationship. For example, if Participant X nominated two people in College, the scored count would only count one for the College category. The scored counts process has a binary yes/no system: did a participant nominate in this specific categorical relationship? Regardless of multiple nominations in a specific categorical relationship, a “Yes” would equal to one, while a “No” would equal to zero. Once each categorical relationship for all participants has been accounted for, all ones were added and represented in Figure 3. Scored counts of nominations to influencers to scientific thinking (Fig. 3) confirms that family had the highest number of participants (24 out of 35) nominating relatives, although college and K-12 educators and staff trailed behind family with 24 and 19 scored counts, respectively.
Meanwhile, at 22% of all nominations, college faculty and staff garnered 101 nominations for influences on scientific thinking. Ten of the 101 nominees have been nominated at least once by at least two participants. Participants nominated the same professor at least once, three participants nominated the same professor at least once and six participants nominated the same professor at least once. Only two of these ten college faculty and staff served more as program directors for honors and scholarship pipeline programs (one in a summer community college research program at a nearby four-year Hispanic-Serving Institution) and have been acquainted with the participants while serving in these positions.

The frequency of nominations may stem from the fact that the participants take very similar classes that are taught by the same professors. For example, all Biology majors have to take General Biology, which is only taught by Professor Racha at the site. Since approximately half of the participants are Biology majors, they can only take this class with him. However, there was still no guarantee that taking the same courses with the same professor would necessarily ensure nomination from participants. There were only two Physics majors and three engineering majors compared to 18 Biology majors, but Professor Banerjee has been nominated at least once by those three different participants. Finally, one of the ten most nominated college faculty was from the Philosophy Department, which is definitely not considered a STEM field.
Participant Juliet Cortez nominated her ethics professor, Professor Rhee, because he influenced her on how she “[justifies] knowledge” when taking a position and asserting her arguments.

Males accounted for more nominations than females; however, when gender data is disaggregated by categorical relationship, female relatives had the most nominations for influence in scientific thinking with 85 nominations.

Figure 4. Race/Ethnicity of Influencers to Scientific Thinking via Relationship

As a whole racial/ethnic group, White nominees have the highest number of nominations when all categorical relationships are combined. The White nominees’ most highly nominated categorical relationship was college faculty and staff with 43 nominations. However, when
categorical relationships are disaggregated by race and ethnicity (Figure 4), Latinx relatives were the most nominated group with 68 nominations.

Figure 5. Influencers to Scientific Observation via Relationship.

**Family Matters**

With 23 nominations, family had the highest number of nominations for influence to scientific observation (Figure 5). When controlling for one maximum nomination per categorical relationship, Figure 6 shows the scored counts of influencers to scientific observation. Still with the most nominated categorical relationship, family garnered nominations at least once from 13 participants.
Participants who nominated family members also shared stories regarding how their relatives have influenced the way they make scientific observations. 26-year-old Latina Physics major Juno spoke highly of her mother who “always told [her] to question things” which “[gave her] the scientific aspect” of observing things in detail; Juno also credited her father and uncle for “always encouraging [her] to look at ‘the big picture’.” 24-year-old Latina Biology major Doni also talked about how her mother “raised [her] to always “be observant” and “aware” and to “speak her mind” on what [she observes].” Both participants have relatives that instilled in them an inquisitive nature when interacting with the world they inhabit, not just while being confined in a laboratory doing an experiment.

In addition, 19-year-old Latina Biology major Suzee described her mother, May, as “the biggest influence on the way [she makes] observations” that she practically “makes changes to [her] perspective every day.” Even though May did not finish elementary school, she has
provided for Suzee, so Suzee feels that she “gotta do even better.” Suzee shared, “she has a huge impact on how I think and feel...she can bring me back, center...and she’s always there, I can always depend on her.” The way Suzee characterized observation goes beyond merely observing scientific phenomena: she viewed her mother’s influence in a holistic manner in that it spills into all dimensions of her life—not just at home or school, but even psychologically.

Family members who were nominated for observation also exposed participants to opportunities for expanding their awareness of the world around them. 20-year-old Latina Psychobiology major, Jewels, reminisced about her aunt, Krista, who is a teacher, “[expanding her] knowledge of the world, [taking] her to the museum, and [reading] books to [them]” growing up.” Meanwhile, 25-year-old Filipina Biology major, Frozen Yogurt pointed out how her parents bought an encyclopedia set and read it to her when she was little. Both participants provided concrete occurrences that demonstrate what it meant to them that their relatives influenced how their worldview changed. Visiting the museum and reading the encyclopedia opened the participants’ eyes to new details to observe and learn. Aunt Krista and Frozen Yogurt’s parents enabled these participants to develop their own skill of observation.

Family nominations also dominated the influence for scientific justification. Figure 7 demonstrates 24 family nominations and 14 college faculty and staff nominations, the second highest group trailing by ten counts. When nominations were controlled by category (one maximum nomination per participant), family still led the number of nominations with 14 nominating participants (Figure 8), which is double the number of participants who named college professors and staff.
Relatives who were nominated for influence on scientific justification oftentimes stood out to participants for their assertive and analytical nature. 24-year-old Latina Molecular Biology major Toro indicated that her sister, Celeste, “always argues with [her]” and “has a strong
opinion on things.” In addition, 24-year-old multicultural (Latina and African American) Biochemistry major Black Swan cited her “smart” older brother as her influence, especially when it comes to “[picking] apart an argument.” These siblings proactively engaged in debates with the participants throughout their lifetimes, providing multiple opportunities in exercising justification of ideas and concepts in varied contexts and topics.

Meanwhile, 26-year-old African Nutritional Sciences major Kaye discussed how her brothers and family in general have affected her scientific justification skills: “My brothers make me believe in myself and be me--try not to be something I’m not, to assert myself. My family always tells me to believe in yourself and what you know, then take a position.” Kaye’s relatives suggested to have confidence in her own knowledge and ability to identify a position on any topic and to “assert” this position she has chosen. Not only did Kaye’s family encouraged assertion of ideas, but also self-agency in sifting through information and determining a stance to justify.

Finally, 27-year-old Asian Chemistry major Stitch appreciated her father for “[teaching] me how to think logical and to know.” Stitch’s father placed value on using “logical” reasoning in justifying arguments and picking evidence that makes sense when backing up an argument. All these relatives provided life-long training in honing the critical thinking skill of justification.

Gender Disaggregation of Family Nominations to Influences on Scientific Thinking

At almost double the number of male relatives (Figure 9), female relatives had the most number of nominations for influence in scientific observation with 15 nominations (versus eight for male relatives). Similarly, among family nominations, participants nominated 15 women relatives and only nine male family members—the highest and second highest number
Figure 9. Gender of Influencers to Scientific Observation via Relationship

of nominations for scientific justification (Figure 10). Eleven of these women nominees occupied matriarchal positions as mothers and grandmothers, while five nominees were sisters of participants. After nominating her grandmother, 27-year-old Latina Aerospace Engineering major Cosmo explained, “Strong-minded Central American women in my family. I put a lot of
emphasis on Salvadorean because it’s part of my identity.” Cosmo showed pride in her culture and values the “strong-minded” women who have raised her.

Even though 24-year-old multicultural (Lebanese and White) Nutritional Sciences major Kat comes from a different background than Cosmo, Kat also proudly nominated her.
“outspoken” Lebanese mother who “taught [her] everything [that Kat] knows.” Kat continued, “My mom recently got fired from a job she’s had for 17 years, but she doesn’t need anybody--it’s their loss. No one can phase her--she still has a positive attitude, Everyone’s attitude represents how they are. I appreciate this outlook in life.” Kat’s mother seemed like an independent woman with her own mind like Cosmo’s grandmother.

Meanwhile, 24-year-old Latina Biology major Doni’s mother inspired the participant to “defend [her] own.” As a young shy girl, Doni’s mother used to get bullied by a Latinx teacher who always picked on her by accusing the mother of being wrong even though she was correct and did the school assignment on her own. Doni’s mother had to defend herself growing up, especially her own ideas to people like her teacher. This inspired Doni to always stand up for her own opinions and principles, whether academic or not. All these matriarchal family figures share an independent mind and outspoken demeanor that have instilled a sense of self-ownership of ideas and proclivity to justifying one’s principles in these participants.

Race/Ethnicity Disaggregation of Family Nominations to Influences on Scientific Thinking

Figure 10 shows that the highest racial/ethnic group nominated for influences to scientific critique were Whites, especially in College and Public figures, which will be discussed in the next section about college faculty and staff. The second highest racial ethnic group were Black family members, which is remarkable since there were only six Black participants (and two mixed with Black participants) and 16 Latina participants (and four mixed with Latina participants).
Black relatives, especially males, made lasting impressions on our participants’ skill in critique. 24-year-old African American Civil Engineering major Roxxy Pain credited her biological father as her primary influence for critiquing evidence, since “he used to [always] challenge everyone.” Having grown up in the foster system, Roxxy Pain recognized her father’s personality in impacting this aspect of her intellect, even though she has stopped talking to him years ago.
Meanwhile, 21-year-old African American Chemistry major Heisenberg appreciated her father (a teacher in Compton, California) for his holistic impact not just on her scientific thinking (scientific critique, justification, and rational thinking), but also on her psychological development from a “shy” and “reserved” person to appreciating social learning (“making friends with everyone in the class”). Heisenberg has “always [been] a pretty good student” but her father always told her to “dream big” because she can evolve from being merely “smart” to being “great.” Her father instructed her that the first thing she should do in class is to “ask for the lesson objective, write it down, and check it.” This classroom practice has trained Heisenberg in record-keeping and using it as evidence of what she was supposed to learn on a daily basis. By
keeping track of this documentation, she can make herself and her instructor accountable for specific dates in school.

Finally, 26-year-old African Nutritional Sciences major Kaye nominated her mother and three brothers for encouraging her to “believe in [herself]” and “explore the information [she] was given.” Kaye’s family trusts her intuition and judgment in sorting through what is factual and what is false.

According to Figures 12 and 13, Latinx family members have the highest number of nominations in influences on justifying ideas and legitimizing scientific ideas and knowledge (rational thinking). However, unlike the justification nominations, nominations for rational thinking have more male Latino nominees than female Latina nominees. When examined in a patriarchal lens, male figures may be seen as figures of authority and credibility; hence, what and who men deem as legitimate would perhaps carry weight as a voice of authority and power. In a light of this similar line of thinking, a patriarchal society’s perpetual scrutiny of women’s thoughts, appearance, decisions, and way of living may condition them to constantly needing to justify their actions—to defend their ideas and, at times, their mere existence.

Nominated relatives emphasized the value of questioning and sticking to facts. 24-year-old Latina Molecular Biology major Toro said that her siblings always “don’t take things on face value” and “question what [something] is.” Toro’s sister and brother have influenced Toro in becoming a critical thinker and fully engage in thinking about an issue, looking past superficial details. Similarly, 26-year-old Latina Physics major Juno shared that her “mom taught [her] to really question” and that Juno “used to stick to facts, but there’s usually a wiggle room.” Juno’s mother also instilled in her a critical mind, which also has space for flexibility. When one speaks of “facts”, it usually connotes constricting to a rigid way of thinking; however, Juno’s mother
recognized that sometimes there may be some gray areas—that there are times when everything is not strictly black or white. This mental flexibility could be seen as another form of looking past the “face value” of situations, in line with digging deeper into the act of questioning. Finally, 23-year-old Latina Neuroscience major Juliet Cortez named her sister for influencing her to always consider “facts.” The sister encourages objectivity, which is a hallmark of scientific thinking. Being objective is part of rational thinking, a way of legitimizing scientific ideas and knowledge.

Figure 13. Race/Ethnicity of Influencers to Legitimizing Scientific Ideas/Knowledge via Relationship.

Again, 21-year-old African American Biochemistry major Heisenberg named her father as an influence to different aspects of her scientific thinking, particularly in legitimizing
scientific ideas and knowledge. Growing up with a single father who also happens to be a teacher, Heisenberg received support from him when she had ideas for experiments: “When I was five years old, we were big cat people. I [always wondered] why some big cats are spotted. Like clouded leopards and margays. Maybe they had a common ancestor? In middle school, I [had] big crazy ideas for a science project. I called Dr. O’Brian at Maryland Cancer Center and he sent [me] genomes of different cat species. [Later], at 18 [years old], I did a project on mice and music in a giant maze. I had mice listen to either no music, classical music, or hip-hop for days and [then] have them do the maze. The only hiccup was that the mice died after I stopped the music. [And some] ate strawberries and died.” Still living with her father, Heisenberg has pursued these ideas with the full support—emotional and financial—of her father. He entertained Heiseinberg’s hypotheses and home experiments, enabling her to test hypotheses even with variables (no music, classical music, and hip-hop). A middle-aged Black teacher in Compton, her father provided the environment for Heisenberg to cultivate her curiosity about the natural world and to perform the scientific method herself.

**College Faculty and Staff Influences**

After female relatives, male college faculty and staff had the second most nominations for influence in scientific thinking. Male college faculty and staff had almost twice as many nominations than the female college faculty and staff (only 30 nominations versus 71 for males). This gender disparity may be due to the underwhelming numbers of female faculty in higher education. Additionally, when categorical relationships were disaggregated by race and ethnicity, following Latinx relatives, White college faculty and staff with 43 obtained the second-most
nominations (Figure R4). Even though MCC is considered a Hispanic-serving institution, perhaps its faculty body consists of a White majority, especially in STEM disciplines.

21-year-old multi-racial (Latina and Lebanese) Astronomy and English double major Jo nominated Professor MacGuyver who taught two Astronomy classes that she had taken and advised the school’s Astronomy Club. Although she did not share specific stories about Professor MacGuyver, she indicated her frequent interactions with him, which also included attending meetings and events of the Astronomy Club, of which she was “the only female [actively participating at the time].”

Meanwhile, 21-year-old Asian American Biology major Eunjung offered more specific examples of why she nominated Biology Professor Racha: taking his class trained her in observing in a “detailed” way, in “[looking] at the steps” and “[giving] more perspectives.” Eunjung continued, “I talk to him individually...he has given me lots of perceptions and knowledge.” 23-year-old Asian American Marine Biology major Mary also took Professor Racha’s course and commented on how his lectures “connect animals that can do stuff [like biomimicry to solve] real world problems.”

On the other hand, 24-year-old Latina Biochemistry major AJ nominated Mathematics Professor Adler, who had “pushed [her] in thinking.” Having taught AJ Pre-Algebra and Calculus, Professor Adler “would not coddle [her class] since as high school graduates, we were supposed to know our times table already and not be afraid.” AJ added, “Maybe he was cruel, but to me, he showed me to do better and that we shouldn’t be scared. I didn’t wanna do STEM because I thought I couldn’t do Math, but I realized that I liked it. He opened my eyes. I started thinking about being a STEM major afterwards.”
Participants met these professors from taking their courses, although it was their extended interactions that made an impact on their ways of thinking. In spite of being the only woman (let alone woman of color) in the organization, Jo’s extracurricular involvement in the Astronomy Club provided her the opportunity for more interaction with Professor MacGuyver. Eunjung’s one-on-one conversations with Professor Racha allowed her to connect classroom information to real-world knowledge. Even Mary testified to the significance of instructors being able to make these real-life applications from mere scientific facts. Finally, AJ also brought up the effect of professors with high expectations of his students to “push” the envelope and their own thinking. AJ believes that Professor Adler did not merely instruct in class, he demanded participation that could make students like AJ feel more involved and engaged in her intellectual growth.

When nominations were disaggregated by gender and race/ethnicity, Figures 14 and 15 show that White male college faculty and staff gained the most nominations for scientific explanation. This may be explained by the fact that there are more White and male college professors at MCC (and higher education in general). Even though MCC’s student body comprises of predominantly Latinx students, the demographic of MCC professors does not necessarily reflect the diversity of the student population.

Participants nominated college professors who they either interacted with directly or made class material relatable to their realities. 23-year-old Latina Botany major Hotdog met her nominee, Dr. Milan, after she worked in his plant biochemistry research lab as part of a federally-funded summer STEM pipeline program that exposes community college students to biomedical research through an internship at a nearby four-year Minority-Serving Institution (MSI). When Hotdog started the internship, she had only taken introductory Biology and Chemistry courses (both for non-majors since she initially did not know that she was going to
major in Biology until after taking these non-STEM major courses). In the course of that summer, she spent a lot of time with Dr. Milan and a master’s student (who she also nominated) in learning about research, biochemical methods, and poster-making. Hotdog recalls when she was creating the poster for the end-of-summer symposium: “Dr. Milan would tell me, ‘This is your thesis statement.’ He took the time to explain what was happening. He corrected me [when I was wrong about something], which was embarrassing but good.” The research internship afforded Hotdog frequent and meaningful interactions with Dr. Milan, who trained her in explaining science through her summer project.

Meanwhile, 28-year-old Latina Biochemistry major Cece looked up to Anatomy/Physiology Professor Armand: “I admire him so much. He completely devotes himself to students. He talks about [his own likes] and relates it to my classmates.” Despite age and race/ethnic differences, Cece related to Professor Armand because he makes an effort to engage with his students. By sharing bits of personal information (hobbies, favorite things, etc.), Professor Armand connected ordinary things to what happens inside the human body. This engaging effort has impacted Cece in the way she describes ideas, scientific or not.

However, college faculty nominations consisted not just of STEM professors but also included professors from the humanities disciplines. 20-year-old Latina Psychbiology major Jewels remarked, “I can’t really think of any science people who influenced the way I explain ideas or arguments.” Jewels then proceeded to nominate two English writing professors, one of which helped her develop her argumentative writing skills. Meanwhile, 24-year-old Asian Biology major Minnie credits two English professors for influencing the way she explains concepts or arguments.
Minnie used to get high C grades for her English writing assignments, in which English Professor Bass would give her feedback that she “did not explain [herself well].” His feedback made Minnie “think that maybe [she is] not explaining [herself] as well as [she] thought so [she] should work on it.” Even though these college professors do not belong in STEM disciplines,
they still trained Jewels and Minnie in critical thinking and effective explanation of ideas and arguments. This may also show that taking general education courses, such as English writing, benefits the intellectual growth of students--honing critical thinking skills that can transcend academic disciplines.

Figure 15. Race/Ethnicity of Influencers to Scientific Explanation via Relationship.

The scientific justification question gathered many nominees of color in the college faculty and staff categorical relationship. Roxxy Pain also nominated in this category: Professor Thomas who taught her first college Mathematics class and emphasized confidence and discipline in students. Roxxy Pain had also never seen an African American woman teaching Mathematics before; even though Professor Thomas was not an engineer, Math was “close
enough to Engineering.” Aside from Professor Thomas’ direct encouragement to being confident in what one studies, she also inhabited a career academic space with rare faces of Black women Math professors--that situation in itself may require a substantive volume of confidence. Professor Thomas’ multi-faceted identities impressed Roxxy Pain, who thinks of this professor when she needs a morale boost when defending her ideas, especially in class.

The few college staff nominated actually belong to off-campus educational outreach programs that particularly expose community college students to STEM research opportunities. 20-year-old multiracial (Latina and White) Biochemistry major Glycine enthusiastically named Program Coordinators Lynn and Larry as influencers to her scientific thinking, especially for observation and justification. Lynn and Larry work at a non-profit research organization that provides internships to community college students so that they can conduct research with scientists on NASA-related projects. Glycine describes, “They taught me to stand by what you believe and continue with it. They’re very motivated, it also makes you feel motivated. They make everyone feel like family and motivate all of us. Every single time I meet them is a favorite memory. They had workshops where they invite alumni interns who talk about how they got there and what they’re doing now...to show how far everyone can go.” Glycine also shares that one of the program alumni is a scientist involved in calculating the Mars landing sequence of the Mars rover who went to community college and now works as a top engineer at the same organization. These Program Coordinators have built a community that is conducive to learning and motivation for community college students. Although they occupy tangential roles to the college campus--i.e., they are employed by the organization not by Marvel Community College--Lynn and Larry still impact the community college interns by providing this unique research opportunity.
Finally, for influences on legitimizing scientific ideas and knowledge, male college faculty and staff have the highest nominations, more than three times the number of females for the same categorical relationship (Figure 16). Many of the male college professor nominees taught compelling material that challenge participants’ way of thinking critically, especially in their STEM courses. 28-year-old Latina Biochemistry major Cece “[loves the General Biology] class” that is taught by Professor Racha: “[He’s] amazing. In lectures, he gave us a book but he always gives more material to make [the material] more relevant to us. [He said that] lots of Biology haven’t been studied. He guided us to specific areas of Biology. In medicine, animals with blue blood...horseshoe crabs...may be preventive in cancer. [They] can’t synthesize their blood [yet] but could be the cure.” Cece perceived Professor Racha’s lectures as engaging, as he introduced a biological fact about horseshoe crabs and their relevance in finding a potential cure to cancer. He “guided” the class in thinking scientifically by connecting a physiological artifact about an animal to broad impacts to human health—using scientific research in determining the feasibility of this biomedical prospect.

Additionally, 19-year-old Latina Biology major Suzee pointed to Physiology Professor Bernal as the professor who has challenged her to “think rationally”: “I’m very spiritual. Super hardcore Catholic, supposed to believe creationism. But [Prof. Bernal] kept it real. He said, ‘we’re funny talking sacks of water and molecules.’ [He also said that] medicine ‘keeps [your body] at equilibrium.’ How are you gonna go against facts?” Although Suzee confessed to being very religious, taking Professor Bernal’s class transformed her thinking about the fact-driven nature of science. Suzee now favors facts and rational thinking over Creationism-related kinds of thinking.
Finally, 20-year-old multicultural (Latina and White) Biochemistry major Glycine nominated Organic Chemistry Professor Azarian: “He explains everything molecular. This taught [me how to] explain everything.” Glycine models herself to Professor Azarian’s detailed explanations about minute chemical particles. Even though electrons and protons may seem abstract and molecular to beginning Organic Chemistry students, performing lab experiments makes them and their chemical properties more observable and tangible. Glycine credited Professor Azarian in expanding her way of thinking--of looking beyond what is (and not) seen by the naked eye--and communicating this scientific knowledge in detailed terms.
Figure 16. Gender of Influencers to Legitimizing Scientific Ideas/Knowledge via Relationship.
Amalgam of Nominations Outside Patterns

After family and college faculty/staff, public figures and K-12 educators and staff have similar number of nominations at 53 and 51 nominations, respectively (Figure 2). Only two public figures were nominated at least once by two different participants: Albert Einstein and Nikola Tesla. Obviously, none of the participants have met either scientist, yet these scientists’ creativity influenced the scientific thinking of our participants, particularly Jodie, who nominated both for all aspects of her scientific thinking. Of the 53 nominations, Jodie actually nominated 25 of them. She is the only participant who has nominated this many in any category, but especially for public figures. Jodie proclaims herself as an avid reader, especially of biographies of luminary scientists like the aforementioned figures.

On the other hand, although most of the participants were born in Los Angeles and attended various K-12 schools throughout Los Angeles County (which includes Los Angeles Unified School District, the second largest in the nation), the huge size of Los Angeles makes it possible for participants to not have attended the same schools and decreases the chance for having the same educators to nominate—even if a school were attended at different years or decades (our participants’ ages range from 19 to 37).

Meanwhile, peers gained a total of 61 nominations, with 31 being schoolmates at MCC and 30 being friends not met at MCC. The designation of “peers” may be somewhat inaccurate, since the participants range in age by almost 20 years (but approximately 24 years old as the average age) and, subsequently, classmates can also range in age due to the nature of MCC (and many community colleges) in attracting students of all ages (in comparison to a stricter age range of “traditional” college students who go to four-year schools). Among the schoolmates, at least two participants were nominated by two other participants at least once: Cheesecake and
Heisenberg. Meanwhile, the non-schoolmate friends became acquainted with participants usually by romantic intimacy (unmarried significant other), K-12 friends, childhood friends, neighbors, or random associations.

Finally, religious figures and local community members also garnered nominations at 22 and twelve, respectively. Two different participants nominated “God” at least once as an influencer to their scientific thinking. For religious figures, the participant Jodie nominated “Jesus, Paul, and Peter” in all aspects of her scientific thinking. However, even non-Judeo-Christian religious figures were nominated, such as Buddha, nominated by participant Bubbles. Meanwhile, local community members included church members, ex-boyfriends who are not friends anymore, and family friends.

Public Figures

For influences on scientific observation, White public figures have as many nominations as Latinx relatives (Figure 17). Albert Einstein and Nikola Tesla equally received the highest number of nominations in this category, which also has mostly male nominations. 21-year-old Latina Chemical Engineering major Jodie nominated mostly public figures, including both aforementioned prominent White male scientists. Jodie admired Einstein: “he has an interesting way of explaining things. He once said, ‘Don’t be a man of success, be a man of value.’ He makes everything simpler; he speaks out of his head, no filter.” Even though Einstein was referencing the ideals of being “a man,” his words still resonated with Jodie. But, who else would Einstein use as a reference? How many of these prominent dead (White and male) scientists would use a woman’s perspective as a frame of reference?
Some of the few women nominated in this categorical relationship are Helen Keller and a fictional TV character named Raven Reyes from “The 100.” According to 24-year-old Asian American Biology major Minnie, she nominated Helen Keller because Keller “didn’t let her disability get in the way of experiencing the world.” Although Keller was not a scientist, she still had an impact on how Minnie viewed the world in detail. However, even though she was a remarkable woman with disability, Keller was still white and visible for her advocacy efforts for the deaf-blind community. How many prominent deaf-blind activists are known mainstream (aside from musicians like Stevie Wonder and Ray Charles)?

On the other hand, 27-year-old Latina Aerospace Engineering major Cosmo nominated Raven Reyes, a fictional Latina engineer. Although Raven Reyes in not a White public figure, she is an anomaly of a television character (in a not very popular television show) in the media, which has a dearth of representations of Latina women—let alone, Latina STEM-based career characters.

Nominated public figures for influences to critiquing information include media personalities that only show up for this type of critical thinking, especially fictional characters and shows on television. 25-year-old Latina Biology major Bibi nominated forensic investigator, Dr. Temperance Brennan, from the TV show “Bones”, while 25-year-old multicultural (East African, Native American, Asian, and African American) Nutritional Sciences major Bubbles credits the crime drama CSI (Crime Scene Investigator); both of these TV shows employ heavy police investigation plots in solving crimes via sifting through varied types of forensic evidence.

Meanwhile, 23-year-old Asian American Chemistry major Jane Dough admitted, “I love TV. When you watch TV, even if it’s not real, you can tell if something’s real or not by listening to the characters.” Although Jane Dough’s nominations (TV shows “Community”, “Game of
“Game of Thrones”, and “The Good Wife”) are not crime drama series like “Bones” or “CSI”, they still give her an opportunity to exercise her critiquing skills by considering character and plot details and their plausibility.

Non-TV public figures include science fiction author Philip K. Dick and motivational speaker Brandon Buschard. 26-year-old Latina Physics major Juno confessed, “I used to read a lot of [Philip K. Dick’s] stories. I try to stay objective as I can—-not just have an emotional reaction--and look at the data.” Juno sharpened her scientific critique skills by immersing herself in Philip K. Dick’s stories, which heavily blends science, technology, and fantasy.

Meanwhile, 37-year-old multiracial (Native American and White) Bioengineering major Ariel likes Bruschard because “he shows a different way of doing stuff.” By exposing oneself to a different method, one can assess the effectiveness or even feasibility of an occurrence. If Ariel can determine how feasible something is, then she can decide if something is real, false, or even plausible.

Unlike other kinds of scientific thinking, justification earned the highest number of nominees of color in the public figures categorical relationship, particularly Black public figures. These public figures primarily came from the field of Engineering and music. 24-year-old Black Civil Engineering major Roxxy Pain named two Black Muslim women engineers: Yassmin Abdel-Magied and Gail Kennard. Also a Black Muslim woman herself, Roxxy Pain first saw a TED talk video of Abdel-Magied, who is a Black Muslim Australian industrial engineer. “I didn’t know anybody who’s a woman of color in Engineering,” Roxxy Pain relates. Not too long after, she attended a local community event in which she met Kennard, a former journalist turned engineer who owns the first Black-owned architecture firm in the West Coast. Also a Black Muslim woman, Kennard actually frequents the same masjids that Roxxy Pain visits from time
to time, so they know each other in the community as well. These public figures have specific identities that have made an impression on Roxxy Pain based on race, gender, religion, and STEM career, especially in navigating a society that considers them a minority and having to assert their intersectional identities in the Engineering field and in society in general.

Meanwhile, 19-year-old Latina Biology major Suzee credited hip-hop music and artists for inspiring her to defend her ideas in any situation and setting. Suzee explains, “I used to be timid, with my li’l voice, and listening to hip-hop...especially Tupac, Eminem, and Nicki Minaj...she’s a big influence. I wanna be like these people and stand up for myself. They came from nothing and now they made it. They got their own. They’re independent, worked hard to get what they want.” Even though these rappers do not pursue STEM fields, their bravado, hard work, and rags-to-riches stories beget confidence in Suzee to defend herself and ideas, as well as encouragement to succeed in life. Influencers can come from any field and still impact participants in the way they think, feel, and act that they then translate to their own schooling careers.
21-year-old Latina Chemical Engineering major Jodie nominated all Public Figures and Religious nominees, for most of the five scientific thinking questions with slight variations (she named a K-12 educator as well); for question five (legitimizing scientific ideas and knowledge), she named all the nominees in the Public Figures and Religious categorical relationships. A self-
proclaimed agnostic turned very religious Christian, Jodie saw no tension between her deep religiosity and profound passion in science. She reads extensively from biographies of Albert Einstein to philosophical texts by Thomas Aquinas, who she nominated for Question five as a man of “faith and reason.” When asked how Aquinas influenced her scientific thinking, she replied, “He follows the ethics and scope of study. I trust most scientists...and if you have a doubt, put it to the test. He also [deals] with people and science. Have you heard of Occam’s razor? Principle of credulity? In Science and Philosophy, the simplest explanation is by far the best explanation. Is it scientific or conjecture? Why do you have to put a front? The straightforward explanation is the answer. Carl Sagan references Occam’s razor a lot.” Jodie appreciated the applicability of this theological philosophy to hypothesis testing and scientific communication. Both Aquinas and William of Ockham (whom Occam’s razor is named after) were theologians and natural philosophers--a common occurrence in the ancient and medieval ages, especially among priests and the like. Similar to these ancient public and religious figures, Jodie embraced the spill-over of religion and science--explaining her constant nomination of public figures and religious icons as influences to her scientific thinking. Like Aquinas, Jodie viewed science as a manifestation of God’s work in the universe, therefore, pursuing science is like pursuing knowledge about God as well. With these public and religious figures being White men, it explains their dominance of the literary canon of science, theology, and philosophy, especially in Western thought.

Peers

Peers on-campus included classmates and schoolmates in general. 23-year-old Latina Neuroscience major Juliet Cortez indicated that when she does not understand a concept in class, her Chemistry lab partner (a Latino STEM major) explains it until she understands. Meanwhile,
27-year-old Latina Aerospace Engineering major Cosmo nominated her Latina classmate who is “a very social science-oriented person yet also interested in science”--this classmate had told her about institutional struggles that STEM students of color face in higher education.

Peers off-campus included friends not met in college. For example, Suzee discussed her childhood bestfriend as an influence on how she critiques information. Suzee elaborated, “She wanna be a lawyer. She has more of a perspective--sees through lies, good at reading people, keeps me in reality. I’m a gullible person and she’s not. She’s my reality check person. She would even tell me if ‘that guy is not good for you, he’s sketchy.’ I’m a LALA person.” Her best friend’s personality has had an impact on how Suzee assesses situations and evaluates ideas and people’s credibility.

**K-12 Educators and Staff**

White high school teachers and staff had the third highest number of nominations in influence on scientific critique; participants nominated teachers of color as well, but since the majority of educators among urban students are White, exposure to STEM teachers of color is not as common as expected. 24-year-old Latina Molecular Biology major Toro credited her high school Mathematics teacher (who happens to be White) for teaching her that in order to evaluate evidence, one should “treat it like a puzzle.” By assuming the identity of an investigator, Toro can assess what fits (or not) within reason and context of all existing factors.

Meanwhile, 23-year-old Latina Neuroscience major Juliet Cortez praised her (White) high school English teacher, Ms. Marino, for teaching her how to “analyze a lot of evidence” via critical analysis of literary texts in class. Similar to non-STEM college professors nominated for
scientific critique, educators from non-STEM disciplines can still help develop foundational critiquing skills that can be transferred to other fields such as Biology, etc.

Aside from honing her critiquing skills, Juliet Cortez’s English teacher also “pushed [her] to apply to college”—unlike her Asian American high school counselor that tried to track her to taking less Science and Math courses. Juliet Cortez told Ms. Marino that she “didn’t want to go to college” until the teacher gave her a pep talk: “Higher education is all we have, especially if faced by challenges such as being low-income.” Even though she “didn’t think [she] would get into any schools”, Juliet Cortez gained acceptance to California public universities and some private colleges, including out-of-state ones. She eventually accepted a scholarship to an out-of-state university, along with funds to study abroad during her first year; however, after being sexually assaulted on-campus and failing to know how to navigate sources to deal with this trauma, Juliet Cortez felt isolated and performed poorly in her classes until she decided to return to Los Angeles and eventually enrolled at Marvel Community College to figure out where she would continue pursuing Neuroscience.

Similar to Ms. Marino, Latino AP Physics/AP Calculus high school teacher, Mr. Marquez, also influenced 21-year-old Latina Biology major Hazel in her scientific thinking and cultivated her passion and “direction” towards a STEM academic path. Hazel credited him for training her to analyze arguments by helping her during nutrition, lunch, and after school. Being the only Latina in the AP Physics and AP Calculus classes filled with only White and Asian students in a predominantly Latinx high school in inner-city Los Angeles, Hazel felt intimidated. Mr. Marquez noticed that she seemed isolated and reached out to help her—even “pushed [her] to do more Math and Science by including her in the school’s MESA program. Hazel admitted to liking Physics and Mathematics in high school, because Mr. Marquez “challenged [her] to do a
lot of Physics.” She adds, “I always ask [him] questions because I trust him...He was supportive in pushing me to do more.” The extra encouragement from Mr. Marquez not only trained Hazel’s skills as a scientist, it also propelled her passion in pursuing the STEM career path.

Hazel also revealed her close relationship with Mr. Marquez’s wife who also happened to be the high school college counselor. “Like [her] mom at school”, Mrs. Marquez “encouraged and uplifted” Hazel in both personal and academic ways. After Hazel’s father passed away, she developed an eating disorder. Ashamed of this condition, Hazel could not tell her own mother about what she was dealing with; fortunately, she trusted this highly sensitive information with Mrs. Marquez, who then referred her to seek therapy and psychological counseling. Aside from “[helping her] in everything”, Mrs. Marquez also “pushed [her] to do heavy Math--AP Physics, Biology, Chemistry, Calculus--and encouraged [her] to go the direction of STEM.” Aside from these contextual details, Mrs. Marquez influenced how Hazel justifies ideas with her “straight to the point” personality.

Self-Nominations

Every participant nominated at least one individual for influence in scientific thinking; however, not everyone named a nominee for each aspect of scientific thinking. Although there are participants who admitted to not having any particular influence on a specific aspect of this kind of thinking, some shared that intellectual processes came natural to them. For example, for scientific observation, Cece said that she is just “naturally meticulous about details”, although she still nominated her mother after stating this.

When asked about any influences on their scientific explanation, Juno and Stitch brought up their strategies when tutoring fellow students. Juno explained, “I explain as though speaking
to a child, through repetition. I do that when tutoring, break down step-by-step.” Meanwhile, based on her experience tutoring high school students during her first year of college, Stitch reflected, “Teaching others helps me how to explain scientifically. It’s the good way, to teach. When you teach your friends, you’re learning li’l by li’l. Like tutoring. I learn better when tutoring others.”

Participants also expressed the same self-motivation in their schoolwork and life in general. When asked about influences to her scientific justification, Jo self-identified as a “stubborn person”: “If I have a belief, I’ll stand by it. I’m very independent when it comes to school. I don’t really ask for help or advice. I figure things out myself.” As the first participant, Black Swan, proclaimed, “I influence them, more than they influence me.” On the other hand, after having confessed to “[loving] learning,” Ariel called herself “super self-motivated.” These statements challenge notions that these participants are only recipients of influence. They also assert the self-agency of the participants. Just because they happen to nominate individuals, it does not mean that these influences necessarily dictate their whole lives--the individual is still in control of their intellectual development.

**Re-Conceptualizing And Measuring Strength of Ties**

Instead of inferring strength of ties (and influence, thereafter) from possible indicators and predictors, this study directly measured the strength of a tie based on the actual influence of a nominee on the scientific thinking of a participant. With scientific thinking characterized as a multi-factor process with five specific elements of the scientific method, multiple nominations in scientific thinking accumulate to a value that is standardized by dividing this value by the total possible number of factors. A nomination in one aspect of scientific thinking equals to a score of 0.20 units; with the maximum nomination equaling five, the maximum score for strength of ties
is 1.0 units. Any negative influence (which only occurred once) receives a negative score with -0.20 units for one negative nomination in any of the five factors of scientific thinking that was tested. The thicker and closer the tie to the participant (ego) in the middle, the more influential these nominees are (and the higher their tie strength score is).

Figure 18 shows two sample sociograms of participants Hazel (18A) and Toro (18B) and all their influences with social ties weighted according to tie strength. Hazel’s sociogram shows that she nominated three individuals once (0.2 units equals one nomination) as influences to her scientific thinking, meanwhile Toro’s sociogram indicates more number of influences and more diversity in the strength of ties in her influential network, with 0.4 units corresponding to her sister Celeste being nominated twice and 0.8 units to her brother Bryan being nominated four times out of five aspects of her scientific thinking. Participants who had more variation in tie strength also tended to nominate more. Relatives have the highest number of strong ties (0.4 and 0.6 units mostly) with 23 total, followed by college faculty/staff with 18 total.

Meanwhile, at the disaggregated analysis of categorical relationship, Figure 19 shows that family members who interact daily with participants have the strongest ties with 11.60 units, which surpassed the daily interaction group median (1.10 units) and strength of ties average for this disaggregation (1.87 units). In second place, college faculty and staff who interact a few times per year with participants hold the next strongest ties with 4.00 units, surpassing the few times per year median (0.40 units) and overall disaggregation average (1.87 units). As a frequency of interaction group, nominees who have never met the participants have the highest overall group median with 6.00 units.
Figure 18. Sociograms With Weighted Ties. (A) Same tie strength. (B) Diverse ties strength.

Figure 19. Frequency of Interaction versus Strength of Ties By Relationship.
In terms of racial and ethnic disaggregation of tie strength and frequency of interaction, Figure 20 reveals that White nominees who participants have never met before have the strongest ties to them with 8.80 units; these nominees are public figures who are ubiquitous in popular culture and science textbooks. Next, with 8.20 units, Latinx nominees who interact daily with participants have the second strongest ties and surpass the daily group median of 1.6 units. These racial/ethnic groups have tie weights that fall outside the range of the average 1.541 units with 95% CI.

Figure 20. Frequency of Interaction versus Strength of Ties via Race/Ethnicity
**Limitations of the study**

Besides demographic information such as race/ethnicity and fields of study, participants come from diverse backgrounds, in terms of age, length of schooling, and academic history; the range of diversity in these three factors may result in variability that may be challenging on the generalizability of the results. However, this diversity, and hence, variability, ought to be celebrated as well, especially since it reflects the reality of inner-city public two-year institutions of higher learning. This variability represents a challenge yet a potential for complex analyses.
Chapter 5

Discussion

“Strong-minded Central American women in my family. I put a lot of emphasis on Salvadorean because it’s part of my identity.”

- Cosmo, participant

When asked about anyone who has influenced “the way [she justifies] knowledge or [takes] a position and [asserts] it”, 27-year-old Latina Aerospace Engineering major Cosmo recalled all of the independent thinking women in her family--in her whole life--and proudly named her grandmother as a primary influencer to the development of the justification aspect of scientific thinking. Although Cosmo’s family has no first-hand experience attending college, let alone studying neither Astronomy nor Engineering, they have supported Cosmo in pursuing this childhood dream. However, perhaps even unknowingly, Cosmo’s family--especially these “strong-minded” Salvadorean women--have actually impacted her intellectually as well: in the way she defends ideas and asserts arguments. With scientific hypotheses drawn from and informed by the culmination of information collection and processing a la literature review mode, justification of ideas and knowledge is one of the most paramount skills that a scientist can develop throughout her career. Cosmo’s upbringing situates her in a familial environment (her home) that has essentially cultivated her intellect in how she justifies ideas and knowledge. There are no rigid boundaries: in many of the study participants’ perspectives, intelligence and ideas traverse worlds--that what one learns at home can be applied to school, and vice versa.
Similarly, 24-year-old Latina Biochemistry major AJ nominated her mother as an influence to the way she explains scientific ideas and arguments. AJ described her as a “tough lady” who “wants reasons for everything [she does].” From explaining daily activities to ideas about school projects or personal goals, AJ has been communicating her ideas, opinions, and rationale to her mother all her life—in a detailed manner that satisfies the curiosity of a probing parent. Perhaps this situation has honed AJ’s skills in communicating ideas clearly in a logical fashion and planted the seminal seeds of reasoning scientifically as a student and later as a summer research intern in a Biochemistry laboratory. Again, participants applied what their family members have told them growing up into their personal and intellectual development; they saw no bounds in transferring this familial wisdom to any other aspect of their life. These stories represent only a few of the numerous accounts of how family has impacted the intellectual development of the participants of this study, who are budding scientists and engineers: women of color STEM majors in a two-year Hispanic-Serving Institution in Los Angeles.

Personally, I found that the most powerful finding in this study has been this outpour of stories regarding family members who have molded the minds of the participants, regardless of education attainment of the parents, grandparents, aunts, and uncles. It confirms how much family matters—even for 24-year-old African American Civil Engineering major Roxxy Pain who ended up in the foster system as a teenager. She still named her father as an influence to how she critiques knowledge, seeing how “he used to challenge everyone” about any claim or information presented to him. Like Roxxy Pain, 37-year-old multicultural (Native American and White) Bioengineering major Ariel has also stopped talking to her mother recently, yet Ariel still named her as an influence on how she makes scientific observations. Although Roxxy Pain and
Ariel are the only participants who admitted to cutting ties with these parents, the rest of the sample group continues to cultivate their strong bonds with their families. Family impressed these women of color with a vibrant environment and rich experience that became formative in the way they think as scientists and engineers now.

Although all kinds of family members have been named as influences to various aspects of scientific thinking, female relatives--particularly, mothers, grandmothers, and aunts--represent a substantial quantum of family nominations. The matriarchal nature of the family nominees implies a gendered wisdom being passed down from generation to generation, from mother to daughter and thereafter. This wisdom could be privy to the matriarchs, with their unique standpoint as mothers (and grandmothers for some), women of color (particularly, Latina), and oftentimes, immigrants in American society, where they traverse along the boundaries of race, class, and gender. These matriarchs pass along the privy knowledge of navigating the home and the world with their daughters (or granddaughters)--the participants who translate these valuable home lessons into the guiding lights of their evolving scientific minds.

I also found it surprising how some participants also named public figures that they have never met as primary influences to the development of their scientific thinking. In stark contrast to the personal familiarity of family, these public figures or entities have become familiar to participants through ubiquity in media and popular culture. Public figures, such as Albert Einstein, permeate the imagination and intellect since they hold visible spaces in society. This explains why most of the public figures named were White and male--that is the pervasive mainstream image of what a scientist or intellectual looks like. If there are more truly visible women of color scientists, then perhaps more of them would be named as influencers to a young woman’s scientific thinking development.
However, some of the public figures are actually also entities or fictional characters on television, such as PBS or Dr. Brennan, the forensic pathologist in the TV show, “Bones.” This may suggest that even imagined characters and stories can spark the intellect, in the same way that mythologies took over the way ancient peoples think and live. It also confirms that diverse media visibility ought to be treated as an urgent matter for inspiring girls and women of color scientists, especially if these fictional characters help our participants in thinking like scientists.

Situating the study in the literature

The emergence of family as a primary influence in scientific thinking among this study’s participants confirms the significance of community wealth capital, especially among Latinx families. This study also contributes the standpoint of an understudied group--women of color STEM majors in the community college--to the feminist epistemological cannon; as a diverse group, these women bring in their colorful perspectives from their own localities as nuanced by the intersections of race, gender, class, and academic field. Finally, these findings have been elucidated through a treatment of critical social network analysis, an emerging subfield of network theory that looks beyond quantitative analyses in making sense of the everyday lived experience of participants. With recent calls for the value of diversity in STEM fields, this study attempts to unpack the impact of a diverse standpoint in the knowledge production of diverse bodies as future scientists, engineers, and STEM leaders.
Based on the findings, family matters not only in supporting students in pursuing their academic goals, but even in cultivating various types of scientific thinking among women of color STEM majors at MCC. This dispels deficit thinking about communities of color and their perceived lack of (higher) education as inadequate mentors for students of color, especially first-generation collegians. The results align with Yosso’s (2005) Community Cultural Wealth model, a strengths-based epistemological perspective from educational critical race theory (CRT) that upholds “the array of cultural knowledge, skills, abilities and contacts possessed by socially marginalized groups that often go unrecognized and unacknowledged.” In particular, Yosso (2005) referred to “familial capital” as “those cultural knowledges nurtured among familia (kin) that carry a sense of community history, memory and cultural intuition.” Furthermore, Delgado Bernal (2002) contributed towards this conceptualization of familial capital from her qualitative studies on the “pedagogies of the home” that Chicana college students can bring with them to succeed in the classroom.

Although the stories that our participants shared do not necessarily fall under the categories outlined in Delgado Bernal’s “pedagogies” (namely, Bilingualism, Biculturalism, Commitment, and Spiritualties) that characterize mestiza consciousness, the collected familial accounts still depict the intellectual nurturing of these aspiring scientists and engineers of color by their family members. In addition to the way a family cares and survives as motivating forces for students to persist in college and beyond, this study would like to extend the breadth of familial capital to family practices that sharpen the mental capacity for scientific thinking. Familial capital encapsulates the perfect term for the family’s influence on our participants’ scientific thinking, since many of the gathered stories feature a multi-layer picture of these
relatives as holistic nurturers of both the mind and the soul of the woman of color STEM major. With Community Cultural Wealth as an epistemological advantage, our findings follow suit since our participants draw on their familial capital in helping them produce knowledge in school and perhaps later on as professionals in the STEM field. This study shows that familial capital provides seminal mechanisms of how diverse bodies (from communities of color) can foster novel ideas and, potentially, innovations in the STEM fields.

*Feminist Standpoint Theory*

The epistemological gains (Harding, 2004) from the de-centered locations of women of color STEM majors at MCC have been elucidated by injecting network methods in characterizing the participants’ locations that feminist standpoint theory emphasizes. By focusing on the ego (the participant, in network theory terms)’s network of scientific thinking influencers, this study places the participant and her lived experience in the center of analysis. The findings substantiate the potentially empowering effect of a participant’s locality and lived experience, especially in Latinx and Black homes.

With disaggregated gender and race/ethnicity data exhibiting extensive influence on scientific thinking from female relatives, especially family matriarchs, the results reveal a matrilinear transfer of knowledge. The transmission passes vertically from mother-to-daughter or grandmother-to-daughter, horizontally from sister-to-sister or cousin-to-cousin, and diagonally from aunt-to-niece. At the intersection of race, gender, class, and STEM fields, the participants thrive in their localities wherein these matriarchs reared their intellect as well as their whole well-being. Plotting the intellectual influence networks of these women of color STEM majors illuminated the familial factors that have shaped their standpoint and skills in scientific thinking.
**Critical Social Network Analysis**

The findings have emerged in light of re-imagining a critical lens of social network analysis. By looking beyond merely employing regression analyses and other quantitative network measures, the results captured more than just numerical data: it captured actual influences of strong family ties and of non-existent ties with famous figures or fictional characters that permeate pop culture and public consciousness. This reimagining of network studies to illustrate complexity from day-to-day activities of participants align with recent work from critical network scholars, Mario Luis Small and Elizabeth Armstrong.

In *Someone To Talk To*, Small (2017) followed a set of first-year graduate students and explored who they named as their confidants for their everyday “worries, concerns, and struggles” and who they actually disclosed such matters in practice. By focusing on the micro-interactions of these students, Small identified that the structure of their network of nominated confidants sometimes differed from the actual people they confided their problems in. The author came to this conclusion through in-depth examination of the everyday practices of these students—a highly contextual approach. His results question assumptions about human proclivity for trusting personal matters only with individuals we share strong ties with.

Similarly, by delving into the day-to-day details of participants’ lives, the results of this dissertation challenges presumptions about the role that family members play—especially those relatives who interact daily with participants—in shaping the scientific thinking of women of color community college STEM majors. Especially with parents who may not have finished elementary or high school, the common expectation is that educators would primarily influence how these students think about science. However, when participants accessed the reality of their lived experience, they named family members—mothers, grandparents, fathers, sisters, brothers,
aunts, and uncles--as seminal molders of their scientific intellect. Magnifying the context of their everyday lives--even beyond the confines of the college campus--enabled this study to paint a complex picture of the networks that influence women of color STEM majors in a community college.

Additionally, this study re-conceptualized the measurement of the strength of social ties in ego-centered networks by directly asking for nominations of influence instead of inferring influence from network connections. Classical network theory employ use of linear regression in analyzing how predictors of presumed factors can predict tie strength and, hence, influence on participants. In conceptualizing the strength of weak ties in seeking job opportunities, Granovetter (1973) calculated tie strength based on indicators (amount of time, emotional intensity, intimacy or mutual confiding, and reciprocal services) and predicted job referral outcomes as linear dependency on these factors. In relation to this study, inferring mutual confiding would be complicated due to uneven power dynamics based on age (older versus younger generation) and status (educated professor versus student still seeking a degree); in addition, reciprocity would be difficult to infer since we have no information on whether the participant also influenced the scientific thinking of the nominee (unless they are also participants in the study).

Meanwhile, Marsden & Campbell (1984) based similar predictions of tie strengths on the following indicators: closeness, duration, frequency, breadth of discussion topics, and mutuality. In relation to this study, how long a participant knows an individual may not necessarily reflect how close they are or how intense their relationship may have developed; topics discussed could also vary and not necessarily apply to scientific thinking; and again, inferring mutual confiding would be an arduous task because of generational gaps and uneven educator-student power
dynamics. Even if such indicators were considered, using them as predictors of influence to scientific thinking (and knowledge production in general) may fall short of providing a full picture of who really influences women of color STEM majors, especially since classical studies usually only asks for nominations of best friends. If this study asked participants to name their best friends, more classmates and friends may have been nominated; however, to use such information in speculating how much their peers influence their scientific thinking would now seem incomplete, especially given what the actual results show.

By directly asking them to name their influences to specific aspects of scientific thinking, this study centers participants’ self-agency in determining these influences themselves instead of basing it on indicators that only show a partial picture of what is actually happening. Using multiple questions that underlie various aspects of scientific thinking, influence can still be quantified in a gradient of direct influence. When measuring a specific type of influence in network studies, designing multiple questions that capture various manifestations of that influence can still produce robust quantifiable results.

**Implications to supporting young women of color in the STEM fields**

Implications of this study include centering the standpoint of women of color STEM majors to inform retention programming in the community college, promoting a community-inclusive learning environment that welcomes students’ families, and building sustained relationships with local organizations through science education outreach.

By centering their standpoint, women of color STEM majors become the primary stakeholders in their own retention and success in the community college and beyond. Aside from promoting self-agency through self-determination, members of this particular group benefit
from having their own voices and perspectives inform college administrators, faculty, and staff on the best way to support them. With the myriad pathways that many of these women come from and take, having them self-determine their own primary needs from the college could result in high turnout in campus events and high participation in resource and support services aimed at these particular students. College administrators may supplement the information offered by these students with professional knowledge that the students may not have known before. Hand-in-hand, college officials may see more fruitful participation from this collaborative style of programming.

College administrators, faculty, and staff also ought to strive to create a community-inclusive collegial environment that recognizes local families as valuable prospective and/or honorary members of the campus. As this study’s results indicate, family matters in the intellectual development of community college students, particularly women of color STEM majors. Valuing familial capital may encourage more women of color to include their families in campus events. In addition, instead of thinking that their relatives would not understand what they are currently studying in their STEM courses, these students may share more details about their courses and other academic activities with their families.

Finally, STEM education researchers, faculty members, and advocates can continue forming community connections with local organizations (e.g., churches, after-school programs, community centers, etc.) and sustain these relationships through science education outreach activities, in which these college students can facilitate with pre-college students in surrounding neighborhoods. Aside from rooting current students in becoming STEM ambassadors in their own communities, this informal learning space opens opportunities for families to learn science
together. Such outreach programs provide novel avenues for parents, children, and their relatives to engage in scientific thinking together and build scientific literacy in their homes.
Chapter V Bibliography


