Appendix. Methodological and Analytical Procedures

I have thought of the primary audience for this book as one of educators and administrators interested in making STEM spaces more accessible and equitable for students from historically minoritized backgrounds. For this reason, I have not approached the data presentation or analysis in the way one might traditionally handle an empirical study; my research methods and analytical approach have taken a backseat to the student voices and experiences. It is understandable, however, that readers may be interested in a deeper understanding of my methods—how I collected and analyzed data and how I validated the information presented.

What follows is a discussion of how I selected participants, how I engaged with them in data collection over time, and how I analyzed that data once acquired. It is important to note that, though this was not a study that used participatory action research methods—meaning, students were not co-researchers and did not have a hand in the study design—ethically, I felt it was important to "clear" my written interpretations of those student and mentor experiences early and often. As a first step in the writing up of my findings, I composed individual case study chapters for each student participant that chronicled their time in the program and the observations that I made in light of my research questions. I gave those individual chapters to each student participant to read and comment on and to correct any misconceptions or add additional insight. Only in the case of Ruben, who told his mentor Dr. Martinez he was participating, was a chapter member-checked with a mentor. I had the other mentors member-check my analytical memos. In two instances, mentors declined to engage in member-checking but gave approval to move forward.

In writing this book, I drew heavily on those individual case study drafts to answer my research questions. I strategically chose not to present any data that would reveal participants' identities, except in the case where approval was granted. As a result, many of the written artifacts from the study are not directly presented but are rather discussed in a way to preserve anonymity.

Participant Selection

In August 2015, I received IRB approval from both the Research Foundation of CUNY (IRB#2015-0770) and Northeastern University (IRB#15-09-16). At that time, I emailed the 27 mentors associated with PRISM to introduce the research project and ask if I might speak to them about participating. After introductory conversations, ten mentors agreed to participate (consent was both verbal and written, per IRB); initial data collection consisted of a one-hour semi-structured interview about the mentors' own experiences learning to read and write as

scientists, their writing processes, and their pedagogical approaches in the classroom and laboratory. It is important to note that not all mentors interviewed had students participating in this project, and not all student participants had mentors participating. Data from the larger group of mentors, however, provided important insights about the administration of the program as a whole and about the culture and inclusiveness of the individual laboratories.

At the end of August 2015, I attended PRISM's three-day research training workshop, a required activity for any student wishing to pursue undergraduate research in the program. At that workshop, I introduced myself to the 12 students who attended and anonymously collected their perceptions on the discourse community of science through group discussion that was recorded. I subsequently emailed each student who had participated asking them if they would like to take part in the research (offering a $25 gift card to a major online retailer as incentive). Two students agreed (verbal and written consent were obtained), and I conducted initial audio-recorded interviews in Autumn 2015. In January 2016, I repeated that process with the newest cohort of research students, and I repeated it again in August 2016 and May 2017. A total of 11 students began participation in the study, with five withdrawing at various points due to time constraints for some and due to withdrawing from PRISM for others.

Because the focus of this research is on women and BIPOC students participating in a URE in science, I was deliberate in participant selection—I recruited only from enrolled PRISM students, who are predominantly female and BIPOC. I screened participants for age: only those 18 years old and older were accepted as participants. I did not screen for any other social factors (i.e., socioeconomic class). Also, because the project focuses on development, I intentionally recruited only those students who were just entering the program, often before they had connected with a mentor. In this way, I was able to follow them from their starts in the program, through multiple semesters as undergraduate researchers (including summer externships), and in some cases to graduation.

Data Collection

The data collected for this study included

- 15 hours of semi-structured interviews with mentors,
- 35 hours of semi-structured interviews with the six student participants,
- 32 drafts of student research proposals and ten poster drafts (where applicable),
- individualized proposal feedback from mentors and program staff,
- analytical memos and direct observation of program training workshops, and
- an assortment of textual artifacts produced or read by the student informants (e.g., lab notes).

Data collection involved conducting a preliminary one-hour interview with students before (or just at the start of) their URE, then conducting subsequent 45-minute interviews after they submitted research proposals, at the end of each semester, and in some cases at the point of graduation. On average, this process provided me with check-ins with students once every three months, a long enough span of time for some development to occur but not so long that the students would not be able to recall their experiences in the intervals between interviews. All interviews were semi-structured and largely student-driven,[10] allowing them to develop confidence and us to develop rapport.

I also asked students to save and share with me copies of all research proposals and (where applicable) presentation and poster drafts, including mentor feedback. Where multiple drafts were unavailable (i.e., because a student misplaced a paper file), I posed detailed interview questions about the mentor feedback to both the students and mentors. The level of detail in the recall by students was particularly impressive. In some instances, I collected as referents additional written materials from students, such as laboratory notebooks, papers written for class, and personal notes. While student-mentor phone texts and emails were not available for direct analysis, I also posed interview questions about this material.

I conducted interviews with mentors and administrative staff less frequently than with students. To ensure confidentiality, neither mentors nor staff were made aware of student participation, and vice versa. In one case, a student self-disclosed to their mentor during the study. In that case, after being given permission, I asked the mentor specific questions about the student. Where this was not the case, I asked mentors specific questions about *all* the PRISM students within their laboratory. Since feedback from the program coordinators was also an important pedagogical element, I requested the written feedback they provided on documents for *all* students and parsed these afterward, and my interviews with the coordinators focused on the program as a whole rather than on individual students.

During the four-year period this study covers, I was also able to observe three training workshops (two in person, one virtually) offered by the research program, as well as three annual program symposia in which students publicly presented their research in poster sessions. This provided me an opportunity to observe their public speaking skills. Though direct observation of the students in their everyday laboratory practices was an initial goal in data collection, in the end this was not possible due to conflicting student schedules and the odd hours students worked in the lab (i.e., from 8:00 to 10:00 pm on weekday evenings and on weekends). Further, from interviews I learned that students rarely worked alongside their mentors in the laboratory; rather, they checked in via email or text and met for weekly or

10. By "student-driven," I mean that I pursued what students seemed most interested in discussing at a given moment, connecting back to my research interests as appropriate. This allowed for richer data and also made for much more natural conversation.

monthly laboratory meetings for updates. As such, direct observation of mentoring was not an option. Direct observation of laboratory meetings was also not an option because mentors felt this would be too disruptive.

Data Analysis

My analysis of the data was ongoing and recursive. As Richard E. Boyatzis (1998) notes, "[the] type of information collected both affects and is affected by the unit of analysis" (p. 63); thus, identifying early what the primary aims of the project were and the ways to address those aims was critical. Since student experiences and writing development were at the focus of this study, I decided that my primary unit of analysis would be the individual students themselves because they are "the entity on which the interpretation of the study will focus" (Boyatzis, 1998, p. 62). This decision was methodologically congruent with my selection of the case study approach and led to the selection of appropriate, relevant data streams. As such, I determined two primary units of coding per participant: the student interviews and the student writing.

Student Interviews

From the very start of the project, I transcribed interviews within a day or two of recording them, and I blinded materials as I went to ensure informant anonymity. In the first interview, I asked student participants to suggest their own pseudonyms, and those were used for tracking. Using my research questions as a loose referent, I *initially* coded[11] these interviews inductively, using my interpretation of what was occurring on the page—for example, when a student spoke explicitly about genre or discourse conventions. I conducted this initial step to organize the data and identify preliminary themes (i.e., genre awareness, sense of belonging) across the participants as well as across time. During this process, I identified potential *in situ* codes (such as "the young Padawan" to describe a student's status in the science discipline) as well as quotations that seemed particularly significant to the research questions at hand. This initial step allowed me to see that certain themes surrounding identity and development were present, for example the influence of mentor expectations and "rules" on student confidence and self-efficacy.

Subsequent to this first step, I determined that using my research questions as a more specific referent (i.e., "prior genre knowledge," "mentor expectations") was an efficient way to organize the interview data and that identity-related codes (e.g., "positive identity association") were useful in understanding the level of

11. I did all coding by hand, on paper, rather that digitally. Not only was this approach more in line with my own work style, it allowed me to see, spatially, the changes that took place over time.

affinity the student may or may not have felt with the scientific community at a given time. I coded interviews in batches by student to allow for focus on the individual's experience and development over time.

Student Writing

Rhetorical analysis was the primary method I used to analyze student writing. I assessed the students' use of rhetorical devices to determine the proximity of student writing to scientific discourse conventions. I coded proposals and other textual artifacts produced by students for rhetorical conventions of scientific discourse, using Ken Hyland's (2005 & 2012) and Swales' (1990) work as referents. This analysis included noting changes between revisions and involved the consideration of tone, point of view, use of jargon, rhetorical conventions, and genre conventions.

I also examined feedback from mentors and staff members, looking for pedagogical moments and for their reconciliation with scientific discourse conventions. I used as referents for coding for context descriptors of strong scientific writing provided in interviews by mentors and staff members, since mentors and staff members were the ultimate evaluative audience for (and instructors of) the writing artifacts students provided. I also took into account tone of feedback and clarity of instruction.

Finally, I identified intertextual and interdiscursive elements (what broad, social currents were affecting the text; how individuals were being positioned in the laboratory or in their science disciplines broadly). I used the results of this multi-dimensional approach to triangulate with student and mentor interviews in order to explore my research questions.

Analytical Approach

The overarching, guiding foci for this study—understanding the ways in which students from underrepresented backgrounds in STEM education negotiated disciplinary discourse conventions in a URE and the impacts of those negotiations on scientific identities—are complex ones. In pursuing these lines of inquiry, what I have been interested in discovering is how women and BIPOC students learn to present themselves as scientists in written and spoken discourse and how their reading and listening practices change to be more or less in line with the practices of professional scientists. Importantly, I have been focused on the role social factors like race/ethnicity, gender, and socioeconomic class play in this development. To answer these larger queries, I broke out sub-questions that would help elucidate different facets. While not all of these questions are answered directly in this book, they all aided in helping me answer the questions identified in the Introduction: How do the norms and expectations of higher education and STEM, specifically, impact the development of scientific identity and discursive skill? What role do societal markers like race and gender play in the negotiation

of identity in STEM learning environments? What follows is a description of the analytical approach I took in attempting to answer each of these questions.

How Is Disciplinary Discursive Development Mediated by Prior Knowledge?

In this research, I used the term "mediation" to refer to the influence of various factors on disciplinary identity and writing development. In this sub-question, for example, I was interested in how students' prior knowledge with science, writing, reading, etc., might affect the ways in which they present themselves as scientists. Drawing on the work of Mary Jo Reiff and Anis Bawarshi (2011), I approached this sub-question by asking the following questions:

- What experiences with reading and writing scientific materials do students report having had prior to joining PRISM?
- Which scientific genres are noted, and what associations (positive, negative, or neutral) do students report having with those genres?

Because this project is deeply connected to agency and identity, I also asked,

- What relevant educational experiences do students report having before becoming a student at the college and before becoming an undergraduate researcher?
- What identities have been applied to students prior to joining the program by family, community, and education professionals?

Prior to analyzing the student interviews, I prepared by brainstorming the ways in which answers to these questions might show up in the data: students might have reported having had a high school experience that was very focused on STEM disciplines (i.e., at a magnet or charter school) or having grown up with scientists (chemists, doctors, pharmacists, etc.) in their family. I also noted that I might find the opposite: students reporting limited exposure to science coursework before college or having grown up with family that had a distrust of science or that questioned its viability as a career. In terms of reading and writing skill, it was important to know how students identified with the acts of reading and writing (as well as speaking and listening) as they entered the program. Had they adopted an identity as a "strong reader" or "bookworm"? Had they been told by others that they were academically gifted or challenged?

In the case of this sub-question, I was interested in learning not just what students knew about *science* before entering the program, but also what they knew about *themselves.* When reviewing and coding transcripts, I looked for moments when students talked about how they came to the program, what sorts of experiences they had with regard to science as a discipline, how they saw themselves as readers and writers, what their perceived ideas were about the kind of reading and writing scientists do, and what they considered "good" scientific writing.

As Reiff and Bawarshi (2011) noted in their research into the influence of prior knowledge on genre transfer, relying "on students' *reported* cognitive processes and retrospective reflections has its limitations" (p. 317). Like them, I was cautious in my analysis because students are not always aware of their skill level, their transfer of knowledge from one space to another, or even the social circumstances that have helped construct their identities. At the same time, I knew that the lived experience of the students—*what they believed about themselves* as they entered the program—would be paramount to understanding their development of discursive skill and scientific identity over time.

Prior knowledge also had direct implications for the other sub-questions I explored. It affects genre, mentoring, cultural considerations, and program expectations and requirements. I used this interweaving to the study's benefit by using the prior knowledge question to address elements of the other four. I was able to identity the scientific genres each student had exposure to prior to joining PRISM, for example, including both macrogenre types (such as article summaries) and situated rhetorical genres (such as abstracts and scientific posters). This was important because, in terms of identity work, the different genres serve very different purposes. Summaries allow a student to demonstrate comprehension and knowledge of difficult scientific content, while abstracts allow a student to demonstrate knowledge of the discourse conventions of the discipline. One speaks to content, while the other speaks to form. Some students excel in one form (e.g., summaries) because it allows for rhetorical leniency, while others excel in other forms (e.g., proposals) because of their strict language rules and perceived formulaic, plug-and-play structure.

How are Scientific Writing and Identity Development Mediated by Mentors and Mentoring?

The influence of mentors on the scientific identity and discursive development of these students was also of importance. Mentors—primarily faculty, but also peer—play critical roles in students' research and practical science education. They also have varying approaches to teaching the reading and writing practices of professional scientists. While every individual's reading and writing process is different, the end results must conform to the discourse community's expectations if the work is to be seen as credible. Thus, the bar I set for defining "professional" level writing was that of the scientific community's expectations on style, genre, tone, etc.

For this question, I was interested in learning how the mentors' instructional styles (e.g., explicit genre instruction) as well as their requirements and expectations (even their own writing styles) assisted or restrained student development of the discursive practices of the scientific community. This involved identifying how mentors guided students in the proposal, poster, lab notebook, etc., writing processes, as well as in presentation preparation. Reading was also important, so

I examined the ways in which mentors explicitly or implicitly taught their students how to read scientific material. As I engaged with the various data streams, I consistently asked,

- How are mentors cultivating scientific identity in their students?
- What *kind* of scientific identity, if any, are mentors cultivating?
- How involved are mentors in instruction about scientific reading, writing, speaking, and listening practices for their students?
- What does that instruction *look* like?

These data largely came from interviews with both mentors and students but also arose from examinations of textual artifacts for comments and modeling of discourse conventions. From prior experience with the program, I knew that there were widely disparate approaches to mentoring and to discourse instruction particularly. There was a wide continuum in approaches to instruction, and I was interested in learning what effect these might have on students' own discursive and reported scientific identities. As such, when examining both student and mentor interviews, I looked for moments when either spoke about the mentor's reported approach (or actual practices) with students in the lab. This included how mentors spoke to their students, their expectations for language use, documentation procedures, and other activities that constitute the *being* of a scientist. In examining textual artifacts, I similarly looked for moments when mentors explicitly or implicitly instructed students in the discursive practices of scientists as well as looked for "teaching moments" that were *not* taken up.

How is Disciplinary Discourse Development Mediated by Scientific Genres?

Much of the communal discourse in science takes place through specific scientific genres: research proposals and reports, scientific articles and brevia, etc. In order for individuals to be recognized by other scientists *as* scientists, their successful engagement with and performance of scientific genres is critical. In posing this question, I was interested in discovering how the students engaged with different scientific genres and whether success or failure in one influenced success or failure in another. For example, if students wrote literature reviews as part of their early research, did that help them in their first proposal writing process? Also, how did their experience with writing in a genre change over time? Did the proposals get stronger semester to semester? Stay the same?

How is Disciplinary Discourse Development Mediated by Program Requirements and Expectations?

As an undergraduate research program, PRISM instituted various requirements and expectations (both explicit and implicit) for students. Explicitly, students

must have been majoring in forensic science, computer science, or cell and molecular biology, as well as have possessed *some* interest in an advanced degree. Before partnering with a lab, students were required to attend the research training workshop, where they discussed scientific ethics, conduct, and professional and community responsibility, as well as more practical aspects of scientific methods, such as literature searching, record keeping, report writing, and basic laboratory techniques/protocols.

Though institutional factors could have been a study unto themselves, by focusing on program requirements and expectations in this sub-question, I was interested in exploring whether the requirements and expectations of the program itself—not the mentors—influenced the students' discursive identities. In exploring this question, I needed to pay close attention to the ways in which students spoke of engaging with the various deadlines, samples, and procedures of the program, asking of the data the following:

- In what ways, if any, does the way *staff enforcement* of genre requirements (i.e., proposals, posters, abstracts) influence the ways students write/approach the documents?
- Do students see the research proposal as simply a hurdle to be jumped or as a heuristic for their research process?
- How do program requirements influence the ways in which students present themselves discursively?
- Are program expectations reasonable and clearly identifiable by students?

How Are Scientific Writing and Identity Development Mediated by Race, Gender, Socioeconomic Status, and/or other Societal Markers?

How people approach an identity is influenced by that identity's prevalence in our culture. Science-related fields are typically perceived as fields that pay well; thus, socioeconomic factors play a role in whether an individual sees a science-related career as a viable career path. Science disciplines are also predominantly White and male; thus, underrepresentation influences how members of underrepresented communities approach those disciplines (National Center for Science and Engineering Statistics, 2015). Since STEM fields are also often perceived as "sterile," free from human emotion, and place where only measurable proof has value (as described by students in this study), entering these spaces can likewise present conflicts for those who have deeply rooted religious beliefs or draw on ways of knowing that do not conform with traditional STEM ontology. Thus, when considering this question, I was looking to see if and when issues of gender, race/ethnicity, religion, socioeconomic status, or any other societal marker became salient in the data, and if is, if those issues influenced whether or not students engaged with or successfully took up the conventions of scientific discourse. Part of this question also connects to students' future career intentions, as that is at

least in part a socioeconomic factor. Students' motivation for getting into a science-related field also presented useful information for exploring this question.

Given the context of the institution (an HSI and MSI), as well as the social circumstances in which this research was taking place (i.e., during the 2016 presidential election and subsequent administration in which race and gender issues were prominent), I sought to identify ways in which these historically underrepresented individuals embraced, pushed against, and/or disrupted the rhetoric of science, both as an embodied practice and as a discursive one. To that end, I regularly posed questions of culture and social factors, with an eye toward answering the following:

- How do students perceive the community and culture of science disciplines before, during, and after their URE?
- In what ways are gender, race/ethnicity, religion, socioeconomic status, or other cultural identifiers embraced, rejected, or ignored during the URE?
- Are any cultural identifiers absorbed as part of these students' discursive identities as scientists and, if so, how are they made apparent?

Analytical Method

Throughout this study, after each interview with a student or mentor, I composed analytical memos to describe what I thought I was hearing come out of the conversations as related to my research questions. These memos included notes about tone of voice, such as whether speakers were assertive or hesitant in their discussions of particular topics, as well as ideas the conversation made me think about. I referred to these memos later during my analysis of transcripts and written artifacts, asking myself whether what I noticed held up against the data. In subsequent interviews with the students and mentors, I often brought up the observations noted in my memos to ask participants whether what I noticed was accurate or off base. In this way, my analytical method was recursive and reflexive throughout.