PATHWAYS INTO STEM AMONG LOW-INCOME, URBAN IMMIGRANT EMERGENT BILINGUAL/MULTILINGUAL YOUNG ADULTS: OPPORTUNITY, ACCESS, AND PERSISTENCE

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ABSTRACT

Pathways into STEM Among Urban, Low-Income Immigrant Emergent Bilingual/Multilingual Young Adults: Opportunity, Access, and Persistence

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This project builds upon the author's multi-year critical ethnographic study of urban immigrant students and their trajectories into STEM (science, technology, engineering, or mathematics) from high school through their transition to college. At its core, this study investigates the paths of over three dozen newcomer immigrant English language learner students in high-poverty urban neighborhoods who are not generally considered “legitimate contenders” for Bachelor’s degrees in STEM fields on the basis of such characteristics as test scores, high school and prior preparation, and age. The students are followed through their high school experiences, their transition to college, and through their current progress in college, with explicit attention paid to key mediating experiences and relationships in and especially outside of the classroom that were associated with their toward persistence and success. Thick description and analysis of the students and their experiences, among those who persisted as well as the minority who switched out of STEM majors, helps to demonstrate a proof-of-concept of these students’ ability to succeed while painting a comprehensive picture of their march forward to degrees in STEM fields against a backdrop of economic, linguistic, and other barriers to entry and success. Using a framework of social and capital and resilience theories, this work has uncovered a number of themes and factors that will help educators to better understand the evolution of these traditionally marginalized students' STEM-related interests, skills, and career plans. The findings center around students’ exposure to research internships and other STEM enrichment

and outreach experiences, long-term mentoring and other key relationships, and integration of STEM and college access efforts in setting them up for a successful transition to college, as well as an emphasis on the importance of students' calling upon their own resilience and other strengths and prior experiences. The results provide novel insights and recommendations for improving access and persistence in STEM among students in areas of concentrated poverty who are also struggling with mastering a new language and a host of other challenges.

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Dedication

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Chapter 1

INTRODUCTION

President Obama and his team of science advisors have set a goal of producing one million college graduates in Science, Technology, Engineering, and Mathematics (STEM) fields over the next ten years, beyond the three million projected based on current rates of production (President's Council of Advisors on Science and Technology [PCAST], 2012). The PCAST report notes that the nation's education system has successfully produced generations of scientists and engineers, but acknowledges that changes may be not only imminent, but necessary, in order to achieve this 33% increase in the education of STEM professionals, by systematic analysis and implementation of evidence-based reforms of undergraduate science programs (PCAST, 2012). The president's advisors also presented the urgency of pre-college, K-12 education to prepare all citizens for proficiency in STEM, and to achieve the increase in STEM professionals by focusing on the dual goals of preparation and inspiration of students in and outside of science and mathematics classrooms (Holdren, Marrett, & Suresh, 2013; PCAST, 2010), extending from the "Rising Above the Gathering Storm" report released by a joint commission of a selection of the nation's premier groups of scientists (Committee on Prospering in the Global Economy, 2007).

Beyond the importance of meeting these goals for securing the overall health of the United States as a continued world leader, the advisors also state that in expanding the STEM pool, opportunities are ripe for meeting the social goal of reducing income inequality as a more diverse group of talent is tapped to create future science and engineering experts (PCAST, 2010; PCAST, 2012). The nation was declared to be at risk thirty years ago (Gardner, 1983), and as

today's reports continue to cry out for new and improved reform efforts, a shift in perspective may be necessary from a singular focus on curricular reforms and increased accountability to consideration of the thorny questions of who truly has access to a quality STEM education. As myriad reform rhetoric has come and gone, new frameworks for critical analysis of opportunities and access have arisen through the theoretical development of human capital, including social capital and cultural capital (Bourdieu, 1977a; Bourdieu, 1977b; Bourdieu & Passeron, 1977; Coleman, 1988).

PURPOSE

The United States is becoming increasingly diverse along racial and ethnic lines. The demographic shifts are borne out clearly in changing public school enrollments, but large numbers of the nation's children fall through the cracks of the educational pipeline, many with hardly a chance to enter the burgeoning STEM pipeline. Over eleven million Latinos of school age reside in the United States, nearly half of whom are English language learners (ELLs); overall, over two-thirds of ELL students are Latino, and the number of ELLs more than doubled over the course of the 1990s and early 2000s (Cavallo & Gomez, 2010; Musetti & Tolbert, 2010). Over two-fifths of Latinos in the US lack even a high school diploma at a time when postsecondary credentials are increasingly necessary for a foothold into the middle class (Musetti & Tolbert, 2010). Within New York City public schools, the nation's largest school district, 40% of students are Latino and about one in seven students is officially considered an ELL at a given snapshot in time (New York City Department of Education [NYC DOE], 2014). Latino students have the lowest on-time graduation rate of any group by race/ethnicity in New York City schools, a meager 52-54% over the five most recent graduating classes, and those who enter

high school as English language learners fare even worse, at just 32-41% over the same time span (NYC DOE, 2014).

Moreover, those who do graduate often attend schools with few to no working laboratories and with college preparatory-level (AP/IB or even Regents-level) science and mathematics courses that are few and far between. It is not uncommon in the Bronx, the nation's poorest urban county, for low-income Latino students and ELLs, mostly from Latin America but also from West African, South and Southeast Asia, and other locales, to earn a Regents diploma (among the minority who actually reach this goal) without completing college-preparatory mathematics courses such as trigonometry or pre-calculus, or the quantitatively focused chemistry and physics courses taken for granted by so many other American students. If such a student wants to enroll in a calculus class through a local public university dual-enrollment program, the closest location may be 60-90 minutes away, and the dual-enrollment program's coordinators have been known at times to question Bronx ELL students' readiness for a calculus course or for other rigorous college courses taken at more prestigious campuses in Manhattan. A recent nonprofit startup that aims to spread awareness and expertise in technology, computer science, and engineering fields to students in underserved New York City neighborhoods has told this researcher and practitioner that it cannot expand to the Bronx at this time, despite an interest in working with ELLs, because no volunteers want to go there.

This frequent dearth of access extends further to a deficit approach taken by some state-funded and college-coordinated enrichment programs, including some focusing explicitly on STEM, who have trouble looking past low-income, recent immigrant ELLs' standardized test scores and current language proficiency. A variety of selective colleges, even some opportunity or access programs within them, that claim to express a strong interest in diversity and expanding

opportunity find themselves viewing recent arrival ELLs as too great of a risk, failing to consider the asset of being fluent in two, three, or four languages, and of the resilience to learn English as a second – or third or fourth – language as a teen or young adult, all the while shoring up academic skills that often reflect interrupted, part-time, or simply sub-par prior schooling, and concurrently carrying heavy extracurricular, work, and/or family responsibilities. Urban immigrant ELLs and Latinos represent an iceberg of untapped potential, and at a time of demographic "climate" change, finding ways to tap into this human potential is not only sensible, but an issue of civil rights.

I have come into intimate contact with these issues over the past seven-plus years, with my adult life's meaning and energy focused around my work as a founding science educator at a new public high school for 16-21 year-old newly arrived immigrant English language learners residing in one of the nation's poorest urban centers. I refer to myself as an urban science educator, and at times even a hip-hop educator, even as my outward identity, background, and prior academic training would not necessarily lend themselves to such descriptions.

My own identity comprises what may be perceived of as an unlikely set of combinations. If I had not chosen to become a religiously observant follower of my religion, I would never have moved to New York, which led to my work in the aforementioned urban school community where I have formed my adult identity. I have a passion for mentoring immigrant young adults, and while my grandfather immigrated to the United States from Latvia, my home region has not exactly bubbled over with immigrants since the steel mills closed. I come from the Rust Belt of Western Pennsylvania where most of my family has resided for over a century and worked in steel mills and a family cast iron manhole cover business. I was raised in a town where people of different races and ethnicities, and of working and middle classes, live and work in relative

harmony to an extent that I have learned is rarely observed elsewhere in our nation of increasing segregation along racial, ethnic, and class lines.

This is not exactly a breeding ground for the hustle and bustle of life in New York. Where I come from, New York City is a big city we saw on maps and the news, with a culture of materialism, conspicuous consumption, and high cost-of-living that were seven hours and a mountain range away. My father comes from a small, racially homogeneous industrial town in Appalachia and spent most of his adult years working at his father's family business in a post-industrial, working-class mountain-town with 600 people. My mother spent her early formative years in a black ghetto in Pittsburgh prior to moving to a working to lower-middle-class Jewish neighborhood. As a college access counselor today, I wonder what kind of work I could have done with my mother had she been my student, when she had persisted past being marginalized at many points throughout her own childhood and adolescence but always focused on channeling her energy for doing good. She had graduated from an integrated urban school where her class background and family circumstances generally resembled those of students of a different skin color, raising her aunt and uncle's family from age 14 on the way to a labor union scholarship that helped her become a reading teacher in urban schools, and then a homebound instructor for students who cannot attend school for reasons of sickness, injury, pregnancy, or criminal charges.

From a young age, I had enjoyed math and playing with pocket calculators, and by 11th grade, I was obsessed with all things science and math-related. Science and math were my outlets for expression, and my identity was formed by the likes of Math League, Science Olympiad, and local and regional chemistry competitions. Partying and other teen activities, let alone those I see in New York, were generally not part of the equation, plus I was the only

Sabbath-observant Jew in a high school of 1500 and a town of 29,000, such that I was a kind of "other," but I focused on similarities more than differences with my peers.

The script for academic success was quite straightforward, and unless one played football, it was clear that academics were the key to moving forward. The top students were mostly South Asian students, with a few east Asian and white students mixed in, and a smaller number of black students. The high performers' fathers were generally employed as engineers at the local Westinghouse Electric facility, with the students themselves generally aspiring to careers as doctors or scientists. Some students got involved with drinking or smoking or had their own children, and the popular crowd was not exactly into studying, but the 4% of us who took all the advanced classes together steered clear of any of this. Maybe I was just oblivious, but in general I observed that there was a limited margin for error for getting involved in questionable activities, and I was more concerned with reading science books, earning college credits, and earning a scholarship to a good college, of the class that people at my high school rarely attended. When all of my friends got rejected from all the Ivy League colleges where they had applied, and they decided to enroll at good public universities or second-tier local private colleges, I did not think much of it.

I mention all of this background information because my reconstruction of it helps in understanding my arrival at my current work and research. Over time in college, I started piecing together the extremely different opportunities afforded to various friends and classmates of mine, all too often based on their high schools, hometowns, and their parents' jobs. I had found out that of my 5-member high school Science Bowl team, the cream of the crop of science talent and motivation from my high school, the teammate who was first-generation to college decided to leave his four-year college after a year; similarly, another friend who had been one of

my fiercest competitors in academic competitions in middle school, who came from the poorest (and all-white) neighborhood in our district, did not even make it to 12th grade with us. There were a sizable number of relatively strong students at my high school, and dedicated teachers, but I remember when my calculus teacher spoke with a group of us at the end of 11th grade, as we had exhausted the school's math offerings a year early, telling us that none of us would return here as adults.

I realized that my roommates and other friends in college almost always had at least one parent with a doctoral degree, and that many of them had gone to preparatory schools or very academically-oriented public schools. Some of them were not interested in studying science, which surprised me for a while on the basis of nearly all of the strong students I had come across in my high school. Some of my hallmates were smoking and drinking regularly, an activity that to me seemed irreconcilable with caring about school and being a smart, responsible student and young adult. I learned that in one of the wealthy suburbs near campus, drugs were actually popular, and I reasoned that the young people there had such a large margin for error that they could engage in such activities without closing doors of future opportunities. This idea of young people's margin for error ultimately became instrumental to my passion as an urban educator.

I also started learning about something that I would later find was called "cultural capital." Many of my college classmates had an appreciation and understanding of classical literature, theater, and traveling to Europe for vacations, a collection at which I would shake my head and write off as the kind of "high culture" that my friends and I back home did not value. While science answered our questions about the world and was the key to solving local and global problems alike, this high culture just appeared to me as a useless separator of people on the basis of class rites and rituals. I had a professor ask me what he may heard of from my

hometown, and when I mentioned football players, his response was, “No, I mean important things.”

Part of this cultural capital was about connections to elite places and things, and part of it was also tied to the types of conversations that people had with each other. My mother and father are college-educated and earned Master’s degrees at night from a local state college, and growing up I knew I was grateful to be in a household where education was important. Homework was first priority, and where eating dinner as a family was important, even if it meant waiting until my dad made the 42-mile drive from the family foundry business, and if he was not home for so long before going out again to transport a couple of manhole covers. On the other hand, dinner conversations were about topics that to me seemed “normal,” like all things Pittsburgh sports, the cake or cookies my mom would bake the next day, what competitions or tests I had coming up in school, how the garden was growing, and the upcoming weather forecast. We did not delve into politics or literature, and the only items we debated were Pittsburgh Pirates roster moves, why the Pitt Panthers could not win in March Madness, or why my mother felt compelled to deliver a fresh cake any time we had a doctor’s appointment.

Much to my college friends’ surprise, I did not go away to summer camps, I had never used a passport, and (gasp!) had many high school classmates who were not on track to graduate from college. I learned to think about my use of “Pittsburghese” pronunciation and grammatical constructs after writing that something “needed changed” in a term paper my junior year at Brandeis and being told by classmates that speaking like that made a person sound illiterate.

As I became more conscious of class divisions in college, I grew so fascinated with them that I was spending time analyzing my friends’ home zip codes and high schools deep into the night. I saw a lot of students get “weeded out” of science majors, professors who lacked the

interest or passion of my high school teachers while assigning work that was an order of magnitude more challenging and less exciting, and I started thinking about my own trajectory alongside that of my friends and peers.

I became more and more incensed at the elitist and exclusionary nature surrounding the culture of my favorite disciplines within the ivory tower. I had chosen science as an enterprise that brought people together around solving problems for the common good, as in developing novel medications or pushing the frontier of our understanding of medical or environmental issues. If anything, it was subjects like English literature that seemed to be concerned with elitist ends, and consequently undeserving of my energy. Seeing intelligent and hard-working people leave science majors and career aspirations in droves, at least in part in response to various science professors with no investment in engaging, high-quality teaching and a lack of ability to connect with their students, was abhorrent to me. I was able to "make it" and I recognized that my high school chemistry teacher had conditioned me to the level of hard work necessary for success, and I had the good fortune of attending a high school where that was possible as well as a supportive family with parents as role models; however, I felt an impending sense of empathy for the "other," for students who were marginalized in the sciences and often came from neighborhoods and schools at the other end of the spectrum from the prep-school students.

My growing frustration and desire to fight back against the unwelcoming culture of science in the ivory tower helped me in my decision to leave the world of chemistry research in favor of teaching ESL-infused chemistry classes at "BELL" (pseudonym), a new public high school for over-aged recent immigrant students. I moved to a predominantly Dominican neighborhood where many of my students also lived, and without having many friends around me in the never-greet-others materialistic metropolis of New York, my students ultimately

became an integral part of my new community and life. Visiting the homes and workplaces of students and their families in my neighborhood and others further solidified my relationship with and understanding of my students' communities and life-worlds over time. In the early days of BELL, my students and I connected through talking about baseball, and I tried teaching them Science and English, while they helped me become proficient in Dominican Spanish and taught me about West African tribal cultures and politics, a unique type of reciprocal relationship with individuals only a few years younger than myself. A number of them would also come to teach me important life lessons about grit and persevering straight through incredible obstacles.

I was open with students about trying to inspire them to pursue science, about science offering a "golden ticket" toward helping themselves and their communities, and the world at large. I assigned more homework than other teachers and generally had only two or three students meet my true expectations at any one time, but I think that may have been for the best. I would stay with students after school, sometimes until 7:00 or 8:00pm, providing an environment for them to successfully complete their work, and a comfortable space for us to talk about science, their futures and ambitions, challenges they faced, and more.

I may have been trained as a chemist, but it was intuitive to me that connecting with students beyond the classroom and the state standards for chemistry was crucial to motivating them, that connecting the material to their lives and capitalizing on their prior knowledge was necessary, as was utilizing their strengths and leadership skills as classroom captains, whether as TAs or regulators of classroom culture or organization. Other people did not even see my students as high school material, and other students with similar educational backgrounds who were in high school generally never took a college-prep chemistry class. All of that was at the forefront of my mind in my daily fight to expand and level the chemistry playing field. Moving

into advising and counseling students, and bringing paid science internships and other outside-of-class programs to these students was a no-brainer.

My foremost passion lies in connecting with students and talking with them and helping to guide them toward success in STEM fields in college. I struggle on a daily basis with defending and advocating for my students in the face of programs and universities who doubt them or view them as too great a risk. I strive to find ways to make them into contenders and competitors with those from more advantaged backgrounds and who had entered high school with more formal content knowledge and language skills – the vast majority of America – and this has become the essence of my raison d'etre. My research stems from this passion as I try to unpack the mechanisms by which my former students, and those like them, are able to find success as college STEM majors, despite a barrage of academic, socioeconomic, and linguistic challenges and appearing as illegitimate STEM contenders on paper in the eyes of most admissions officers, faculty, and even educational researchers. With average SAT math and total scores around 400 and the low-to-mid-700s, respectively, and a diploma from a high school that never offered a full Algebra II/Trigonometry course, let alone Pre-calculus, until this year, these students do not have the profile of those who will find success at four-year colleges, much less in STEM fields. Nonetheless, over two dozen of these very students are finding success, and I feel compelled to undertake a systematic investigation of just how that has happened, hoping for insights into how to help greater numbers of such students to have similar successes.

At its heart, this dissertation project seeks to elucidate key protective factors in the high school and early college years, from relationships to outreach and enrichment program components, that are most effective in mitigating success in STEM for students whose pre-

college exposure and access to rigorous science and mathematics have heretofore made colleges and researchers consider them exceedingly unlikely to succeed in STEM majors.

RESEARCH QUESTIONS

Based on questions unanswered by prior work, the central research questions to be investigated are as follows:

(a) How do low-income urban immigrant ELLs navigate success in persisting to pursue STEM careers, especially during and after the crucial transition to college period, when they may not, on paper (by test scores, etc.), be considered legitimate STEM contenders?

(b) How do key experiences, relationships, and protective factors impact these urban immigrant ELL students' college and career plans with regard to their interest in STEM?

(c) How does targeted STEM outreach and enrichment programming for these urban immigrant ELLs impact their academic performance, aspirations, and motivations toward STEM fields?

ORGANIZATION

Now that the broader problem has been introduced of needing to broaden opportunities for students from certain communities to engage and enter into STEM majors and careers, the second chapter summarizes prior literature related to equity and opportunity in science education among diverse populations and set up the resilience and social and cultural capital-based theoretical framework that guided the conception and development of the study. The third chapter introduces the methodology of the project, a critical ethnography with some mixed-methods components comprising an overall approach that aims for deep, sustained embeddedness in multiple contexts of the participants' lives and experiences so as to provide as richly descriptive a set of data as possible for the participants over a multi-year span. The participants are students whose "on-paper" characteristics generally preclude them from serious

consideration by the prevailing status quo of most college admissions officers and researchers as contenders for four-year STEM degrees. The study, which follows these students from high school through their current point of progress in college, is explicitly emancipatory in its objective to question and alter prevailing status quos vis-à-vis access and exposure to and persistence outcomes in STEM majors.

The fourth chapter introduces the ethnographer and his insertion and co-evolution with BELL, the urban public high school for 16-21 year-old newcomer immigrant English language learners where he has worked in various capacities and settings related to science/STEM education and college access counseling for seven-plus years. All of the core participants of the study graduated from BELL; moreover, the project follows all students from BELL's four graduating classes to date who matriculated to a four-year college intending a STEM-related major. The fifth chapter delves more deeply into BELL, its unique student population, and its instructional and extracurricular offerings, with emphasis on science-related learning opportunities. Chapter 5 also introduces common sources of motivation and experiences that were common to catalyzing a number of students' early paths into STEM careers, highlighting several students' trajectories into STEM from their lives prior to immigrating to the United States through the time when they were about to transition to college. Chapter 6 picks up where the prior chapter left off in charting students' trajectories into and through college, as well as identifying and discussing key mediating relationships and other variables that impacted students' access and transitions into college, and into their intended STEM majors. While the fifth and sixth chapters offer highly contextualized findings as to the "who" and "how" of persisting in STEM against seemingly great odds, the seventh chapter formalizes, summarizes, and discusses a range of themes that emerged throughout the study alongside a statistical portrait

of the “persisters.” The seventh chapter’s closing analysis and discussion of various supports experiences by the persisters sets the stage for the final chapter. Chapter 8 features conclusions and recommendations for future practice and research driven by feedback offered by the participants themselves to younger peers, teachers, educational researchers, and other stakeholders so as to drive change from the source, or the true experts: the STEM persisters who have repeatedly defied odds and expectations.

Chapter 2

FRAMING THE STUDY

REVIEW OF THE LITERATURE

Class, Race, and Opportunities for Science Learning

In 1966, twelve years after the Brown vs. Board of Education decision that would desegregate, at least legally and symbolically, America's schools by race, the government-commissioned Coleman report demonstrated with a vengeance that separate schools are, in fact, unequal (Coleman et al, 1966). Among the most striking of the report's findings was the strong relationship between school socioeconomic composition and student achievement. Home background and individual student attributes provided significant variation, but in terms of school-level variation, the socioeconomic context of children's schools made a far more significant impact than the curricular or resource-related factors that were studied (Riordan, 2004). Indeed, Coleman suggested that it was the education resources, now referred to as cultural capital, that the students contributed to the school climate from their home lives, which seemed especially important. Another component of the explanation behind the SES contextual effect was that students naturally respond to the standards, social mores, and reward systems recognized and valued by the students around them, notions that correspond strongly with Coleman's later derivation of social capital (Riordan, 2004). While the Coleman report demonstrated that student-level home background or SES effects were important, the school SES context may actually negate many of the benefits (or disadvantages) conferred by the student's own socioeconomic status and human capital of the home. Indeed, a subsequent study found that the college aspirations of low-socioeconomic status (low-SES) students in high-SES schools

increase by virtue of their school environment by about the same percentage as the college aspirations of high-SES students decrease when they attend low-SES schools (Riordan, 2004).

Riordan's review of Coleman as well as subsequent studies found that SES context seemed to be a proxy for academic climate of schools, perhaps related to Coleman's later conceptions of social capital (1988). This raises the question of whether some equivalent for this climate is also at play with respect to the impact accorded to family structure, beyond SES, within school context, as well as neighborhood SES context, on student achievement (Riordan, 2004). Indeed, Patricia Gandara's study of within-group differences of Mexican Americans from low-SES families, profiling children who attained doctoral degrees despite coming from families with limited formal educations and low-wage jobs, found that these "exceptional" cases disproportionately attended more integrated schools and lived in more integrated (i.e. not entirely urban-poor) neighborhoods; interestingly, she also found that these individuals' families demonstrated strong home literacy habits, a type of dominant cultural capital, that would not commonly be expected in low-SES homes (1995). Rumberger and Palardy isolated four school process variables that explained most of the school-level SES context difference in student achievement growth: teachers' expectations, amount of homework completed, average number of college prep/advanced courses taken by students, and feelings of student safety; in science achievement, however, while these factors would seem to be key to programs to expand access to quality education, even they could not fully explain the enormous effects of school SES context on individual achievement (Rumberger & Palardy, 2005).

After establishing the importance of individual and school SES context for learning across the subject areas, one may consider the specific case of unequally distributed opportunities in science and mathematics, or STEM fields, more broadly, and the impact this

may have on the nation's STEM pipeline. In a series of two reviews, educational sociologist and tracking expert Jeannie Oakes reviewed seminal work in this area and also analyzed longitudinal data for further insights into the opportunity structures effecting American students who are underrepresented in science, namely, women, and to a larger extent, African Americans, Latinos, and low-income individuals (1990a; 1990b).

In *Lost Talent: The Underparticipation of Women, Minorities, and Disabled Persons in Science*, Oakes unpacks achievement, opportunities, and interests/choices as the key factors associated with who ultimately enters what is now referred to as a STEM career (1990a). She demonstrates that while African Americans and Latinos (who attended poorer and more racially segregated schools than Whites) are underrepresented among college graduates and professionals across the range of career areas, they are disproportionately underrepresented in STEM careers, even against the backdrop of their underparticipation in professional fields as a whole. In both of her reports, Oakes refers to the idyllic (allegedly) American notion of a fair distribution of opportunities in social, economic, and educational spheres, and she demonstrates that a blatant dearth of such equitable access and opportunity across the elementary through higher education trajectory has vastly limited participation of what has become the underrepresented *majority* (including women) in the scientific professions that are so crucial to the nation's progress (Oakes, 1990a; Oakes, 1990b).

Ultimately, achievement can be seen as heavily impacted by the avenues of opportunities granted to students. Persistence in college science has been observed to be related to such achievement variables as math SAT scores and courses completed, high school grades and rank, and college grades (Oakes, 1990a). SAT scores have been shown to be significantly impacted by socioeconomic status, and community and home factors have been demonstrated to account for a

significant portion of individual variance in mathematics achievement among seventeen-year-olds; this becomes even more problematic when considering that higher SAT scores have been demonstrated to correlate with persistence in STEM majors (Matyas, 1986; Oakes, 1990a).

Oakes also disaggregates the key successful components of programs aimed at leveling the STEM playing field. Important elements include science role models and/or mentors, encouragement and constructive counseling to participate in optional mathematics and science classes and activities, family and community involvement, small-group learning and tutoring, and career information (Oakes, 1990a). She suggests that special programs, like course offerings, be offered to students regardless of their current achievement, so as to open avenues of opportunity for all students to gain confidence and proficiency in STEM, in line with Obama's advisors' recommendations over 20 years later. These supplemental programs are especially important for students whose schools and communities lack the capital to offer them these opportunities, which may be taken for granted in typical upper-middle class schools, or in the homes of students whose parents are professionals in STEM or medical fields. Oakes's second paper (1990b), *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science*, as well as a more recent report by the U.S. Department of Education Office of Civil Rights (2014) further parses out the unequal distribution of course offerings available to disadvantaged students, which makes supplemental programs (and/or, ideally, radically reconsidered formulations of school expectations and course content) especially important.

Through a series of data tables and graphs, Oakes quite poignantly illustrates the multiple layers of disadvantage conferred to poor, minority students in increasingly segregated communities and schools, locking many of them out of even seriously considering the many

lucrative and stable career options available to those who are able to stay in the STEM pipeline. One set of figures shows that schools with nearly no white students also offer far more low-track and less high-track classes than other schools, and that schools in high-wealth communities offer even more high-ability classes than regular-track classes. High-wealth schools offer more than double the advanced science and mathematics courses that are often gatekeepers for entrance (and persistence to graduation) to engineering and science fields, compared to high-poverty schools, per 100 students. A disturbing trend is observed in the eerily linear relationship between school SES and the probability of the school offering algebra (in the case of junior high schools) and calculus (in the case of high schools); additionally, even when course offerings appear similar on paper, high-SES classrooms have more a more intensive academic focus on building college-ready conceptual understandings and skills than low-SES classrooms (Oakes, 1990b). Moreover, every year of high school mathematics completed beyond Algebra I is associated with a dramatic, nearly two-fold increase in a student's chances of earning a Bachelor's degree in any field (Adelman, 2006).

Even when students (of varying family and school backgrounds) do enter college with hopes of entering a STEM career, the pipeline continues to thin, as the majority of those entering STEM do not persist, with the problem becoming especially acute among underrepresented minority groups (PCAST, 2012; Seymour & Hewitt, 1997). Seymour and Hewitt's landmark work, *Talking About Leaving: Why Undergraduates Leave the Sciences*, cites a number of reasons for students leaving the sciences at the undergraduate level, with some of these reasons reflecting the earlier literature in the case of students who were relatively well prepared for college but attended lower-SES schools. Inadequate high school preparation (as aforementioned as nearly inevitable for many urban immigrants and Latinos in places like the Bronx), conceptual

difficulty with the college-level material, lack of familiarity with an intensive, competitive atmosphere, and socialization and support issues were among the barriers faced by ethnic minority students, leading many to switch out of science and some to leave college altogether (Seymour & Hewitt, 1997). An estimated 60% of U.S. students, including over 80% of underrepresented minority students, are already essentially cut off from the potential STEM career pipeline by their early teen years by the courses they do or do not take. While a focus on intervention at the college level has shown some benefits, as will be described in the Meyerhoff and other programs later in this paper, a continued lack of attention to high-impact intervention work at the pre-college level will only continue to remove masses of students from having realistic chances of success in a plethora of STEM-related careers, including especially systemic blockage in the highest-needs communities (Tsui, 2007).

Students' seeming inexperience with the social and cultural capital of dominant groups in STEM (namely, more affluent, white male peers and an overwhelmingly white, male professoriate) was thus an important barrier to these students' success in college. The elitist, exclusionary culture and detached nature of the academic demands that many professors make on students from problems reflecting any social issues or responsibility are further alienating influences, and are also tied to students' distance from the cultural capital of the dominant group at hand (in this case, the science professors who act as gatekeepers) (Tobias, 1990). More recent work focusing on Latino students in STEM majors explicitly links cultural capital, and the related constructs of cultural congruity and campus climate, as the key framework for studying minority student success (Cole & Espinoza, 2008). A qualitative study by Palmer, Maramba, and Daney isolated involvement in extracurricular STEM activities, strong peer group support,

and rigorous high school preparation as the key themes associated with students of color who persisted in STEM majors (2011).

Science for All: English Language Learners and Immigrants

Another useful lens for understanding access into STEM for urban immigrant students, among other marginalized groups, is that of scientific literacy. Prior to the second major wave of science education reform, following the 1983 report, *A Nation at Risk*, the idea of a universal scientific literacy, across race, ethnicity, and class lines, was essentially absent from discussions among science educators and reformers (van den Akker, 1998). The nation's priorities in science education started to shift at that time, as authorities started paying attention to the nation's increasingly diverse public schools at the same time that state and national bodies started setting broad frameworks for learning, and learning sciences researchers came to a better understanding of the individual. This led to social constructivist theories of learning that would set the stage for transformative pedagogical methods to replace the transmission-based models of earlier eras when reform was set in motion without consulting educators or educational researchers (Blumenfeld, Marx, Patrick, Krajcik, & Soloway, 1997; ibid.). Soon, the third and current era of science education reform would start, emphasizing depth over breadth in science learning, alignment of assessment with curriculum, national standards, and responding to three influential national reports from the American Association for the Advancement of Science (AAAS), National Science Teacher Association (NSTA), and National Research Council (NRC), respectively (Eisenhart, Finkel, & Marion, 1996; van den Akker, 1998).

Eisenhart et al's (1996) analysis of four distinct renditions of scientific literacy was especially helpful in setting the stage for the current study. The group's starting point was the unified tone set by the AAAS, NSTA, and NRC reports, which for the first time made clear a

national priority of all Americans attaining considerable knowledge and familiarity in science and mathematics as part of informed citizenship. An ideal of science being applied by all to make responsible personal, social, and political decisions was also set forth by these reports. As outlined by Eisenhart and her colleagues, the science and science education community of the early 1990s had a major weakness in not yet being able to spell out how to realistically achieve their aims for the increasingly diverse youth in American schools; at the very least, however, their positioning of the tools and knowledge of science as keys to attacking local and global problems put such ideas in the national limelight for the first time. Eisenhart's group also presented evidence that as part of the weed-out culture of science, especially at the post-secondary level (for those who even get to this point with motivation to pursue science), those students who are motivated to STEM fields by societal problems are all too often jaded by their experiences to the point of leaving the science pipeline or learning not to focus on the socially responsible aspects of science. Unfortunately, with all of their good intentions, the national reports were quite vague as to how to achieve science literacy for all students, assuming that if standards documents were in place and standards-aligned curricula existed, then students would all learn science at the level suggested by the standards, regardless of social or cultural barriers or constraints (ibid.).

Understanding Keller's continuum of critiques of science, as delineated and expounded by Eisenhart's group, helps to problematize the seeming "lip service" that predominant scientists and science educators seemed to be paying to any idea of true engagement in universal science literacy, or science for all, and to concretize steps that may be taken to move closer to this ideal. Eisenhart points out that the prevailing science literacy movement emphasizes what Keller somewhat ironically called the "liberal" solution, which is the most conservative of the four

possible critiques to the status quo in science. In this "liberal" model, which is in all fairness liberal compared to the curriculum development movements of the post-Sputnik area that continued to focus most of their resources on a select few students (who were primarily white, male, and at least middle class), females and racial and ethnic minority students are to have equal access to opportunities to learn and master science according to state and national standards; however, no mention is made of class, or of English language learners, or of accommodations or strategies to help such students, or the girls and non-white girls and boys, to learn science (ibid.).

Eisenhart mentions the rise of culturally relevant pedagogies to reach and inspire more students to learn science, and also stresses the importance of science that is socially responsible, an awareness of problems extending beyond the walls of the classroom that reflects local and global needs and issues. Such approaches are vital in any efforts that are to draw more students into wanting to learn science, especially in settings where there is pressure not to engage in science or other school-based learning. The joint notion of socially and culturally responsive teaching is at the heart of the course that I am designing, as most textbooks and curricula that are used in urban schools, and certainly at universities, today seem to continue to follow Keller's so-called liberal approach to equity, at best, and simply ignore diverse students' needs, at worst. Eisenhart describes Keller's second level of critique of the status quo in science through a sense of bias in the types of science that has been pursued and funded due to the domination of science fields by males. The third and fourth levels, which are the most radical, are also based on gender differences, but beyond simply challenging the kinds of scientific knowledge that are advanced based on science disciplines' long-term control by males, they also challenge dominant research designs and analyses (third level) and value placed on positivist, objective knowledge and rationalism (fourth level), which are also said to disadvantage women (ibid.).

Eisenhart stresses that the suggestions of the AAAS, NRC, and NSTA would be unlikely to create more opportunities for women and non-white students because they did not call for a break with white male-dominant ways of learning and practicing science. She would then go on to challenge what she feels to be a narrow, Piagetian and radical constructivism that was advocated for in the reform documents of the 1990s, as they do not push the issue of making science material more accessible, socially impactful, and engaging, which would demand a sociohistorical constructivism. Sociohistorically-rooted constructivism features students performing authentic scientific activities and becoming enculturated into a welcoming community of science learning and practice, which helps them to build a science identity (ibid.). These ideas, which form the basis for activity theory, also draw from the core ideas of building communities of practice, based on the conceptual work of Lave and Wenger (1991). While I would like to have seen more of a focus on traditionally marginalized students based on race, ethnicity, class, and first language, and not only on gender, Eisenhart's paper lays a strong foundation for evaluating a new program or course's impact on expanding science literacy, and also leads naturally to discussions of student identity as well as learning sciences-oriented theories of situated cognition, authentic and anchored learning, and communities of practice, and their potentially synergistic impacts on student motivation and learning.

Before moving on to these discussions, it is fruitful to first consider alternate conceptions of scientific literacy and expanding access to science learning to more students. Okhee Lee, a predominant scholar on English language learners and other student groups who have long been marginalized from science and other academic areas, echoes many of the critiques of Eisenhart but also emphasizes the importance of valuing and utilizing non-dominant, non-Western perspectives (1997). She advocates an expanded version of what is recognized and valued as

science, arguing that more students will be motivated to learn science if it is more closely aligned with their cultural mores and identities. Lee recommends expanding the boundaries of normative scientific practice to include cooperative learning as well as socio-emotional support, and she points out the hegemonic Western nature of what passes for science discourse in the dominant scientific community (ibid.).

As the study focuses on a generally-overlooked group of students – older high school students who are recently-arrived immigrant English language learners (ELLs) in a low-income urban center – some understanding of recommended practices for such students would be recommended. While a fair amount of research has been conducted with English language learners in science classrooms over the past couple of decades, it focuses almost entirely on elementary and middle school students (Lee, 2005). What we do know about high-impact practice with low-income ELLs is that language development work should occur alongside disciplinary content learning (sometimes referred to as part of the "sheltered instruction" approach), rather than having students focus only on learning English and falling further behind their mainstream classmates, and that students' aspirations to continue studying science depends in part on an awareness of college access and opportunities (Musetti & Tolbert, 2010). Without much specialized ELL literature to refer to, it seems reasonable to consider this population amongst many that have been all-too-frequently disenfranchised from science, and school in general, by a combination of policies and culturally exclusive practices.

On the policy level, the ability to effect positive change in this arena is closely related to public opinion and policy as related to immigration and to Latinos/as, who comprise the largest group of immigrants and English language learners in American schools. Politicians as well as economists, sociologists, and others will continue to debate the costs and benefits of immigrants

and of immigration policy, but it must be clear that investing in the education of all students in American schools will ultimately result in the greatest net gains for all individuals and for society at large. Through Plyler vs. Doe and other Supreme Court cases, it has been established that all children in this nation are entitled to a public education, with individual states as well as national momentum ebbing and flowing with support for an extension to include funding and future prospects at the higher education and professional levels via state and national DREAM Acts.

At the same time, however, it is known that low-income urban immigrant students disproportionately attend schools in areas of concentrated poverty that have limited human and material resources. To add insult to injury, anti-immigrant sentiment in California, Arizona, Georgia, Utah, and other places throughout the United States has led to bans on students using their native languages in the classroom (an ode to practices from the turn of the 20th century), on bilingual or multilingual education, profiling immigrants and English language learners, even prohibiting undocumented immigrants from attending colleges even if they do have a means of paying (Contreras, 2011). While differing economic and political analyses will inevitably lead to heated discussions over whether immigration has negative consequences for some members of the American populace, such as the semiskilled and unskilled working classes, a recent analysis suggests that these concerns over crowding-out labor effects and other issues are overblown by nativism and ethnocentric thought, and that overall, the United States and its people experience considerable net social and economic gain from immigration inflow (West, 2011).

The use and proliferation of languages other than English are highly charged issues in the United States, an ironically, doggedly monolingual country in an age of globalization where other leading nations routinely expect their citizens to master two or three languages. Language

acquisition theorists – and employers in a variety of fields – have shown time and time again the value of mastering multiple languages, and yet students in US schools who speak one, two, or sometimes three to seven languages (especially in the case of students from places like tribal West African regions) are judged only by the very accountability measures developed and validated for middle and professional-class students. In an age of standardized test-based accountability and decision-making that directly impacts students' ability to graduate from high school, and have a huge impact on the way that even very holistic college admissions offices evaluate them for admissions (and financial aid), it is clear that standardized assessment validity and reliability does not hold up across diverse student groups, and that English language learners are actually at a more distinct disadvantage than other non-dominant students (Noble, Suarez, Rosebery, O'Connor, Warren, & Hudicourt-Barnes, 2012). Thus, the trifecta of being poor, a member of a minority group, *and* an English language learner who arrived around the age when these exams are taken sets up a perfect, synergistic storm for wildly invalid evaluation of a student's content and skill mastery and future potential.

Social and Cultural Capital

Coleman's conceptions of human capital can provide a means of unpacking and understanding these and other opportunity structures in education (1988). Coleman introduces the concept of social capital, which comprises the benefits derived from the relationships between people. The advantages of a person's social capital stem from the set of helpful information channels and networks, effective norms and sanctions, and other characteristics of the social environment (namely, expectations, obligations, and trustworthiness) (Coleman, 1988). Coleman demonstrates that social capital is a crucial part of so-called "family background," and in terms of student achievement, it describes the advantages (or disadvantages) that a student

derives from interactions with the parent(s). As an example of strong or "high" social capital, Coleman discusses parents who spend considerably large amounts of time and effort discussing or teaching their child about a given topic or subject (1987). In the context of schooling, social capital also arises in cases such as the networking that middle-class parents often undertake with teachers and other school staff, and with each other, in order to ensure optimal educational opportunities for their children in a way that is often foreign to working-class parents, whose networks are often more kin-based (Coleman, 1988; Lareau, 1987).

Coleman also discusses other forms of human capital relevant to students and their opportunity structures, such as their parents' ability to provide them with an environment to assist the student in learning, which is often approximated through the parents' level of education (1988). The home environment and overall milieu in which a child grows up is deeply impacted by the cultural elements most valued by their parents. The benefits provided by these cultural attributes of family life are exemplified as cultural capital (Bourdieu, 1977a; Bourdieu, 1986; Bourdieu and Passeron, 1990). The cultural experiences afforded by a child's family represent important, class-dependent intangible resources that Bourdieu theorizes to deeply impact children's school performance (1977a). Lareau continues this discussion in her study of elementary schools in working-class versus middle-class areas, demonstrating the value-laden expectations of schools as aligning mostly with what Bourdieu would refer to as middle-class *habitus* (Bourdieu, 1977b; Lareau, 1987). Various manifestations of cultural capital are developed that hold possible links to school achievement, from families' structuring of after-school activities and leisure time to an appreciation for the artistic traditions of "high culture," from having books and newspapers at home to feelings of social empowerment (Lareau, 1987; Sacks, 2007). The high worth traditionally attributed by schools across the socioeconomic

spectrum to the social and cultural capital possessed by the dominant elite (upper-middle and upper classes) place children from other backgrounds at a distinct disadvantage even before they set foot in the classroom each day (Sacks, 2007). Moreover, the greater the distance one's own social and cultural capital falls from that of the dominant class, the less valued one's social networks and cultural mores will be, and the less helpful they will be in fostering social mobility.

THEORETICAL FRAMEWORK

Two of the most compelling current frameworks for untapping potential and encouraging success of diverse populations in STEM have, at their roots, an emphasis on cultural and social capital that will be key if the United States is to maximize the intellectual and professional gifts of its people, regardless of the zip code into which they are born. Graham, Frederick, Byars-Winston, Hunter, and Handelsman's persistence framework emphasizes learning communities as well as early affiliation with a scientific research community – both forms of social capital that also build cultural capital – and active learning opportunities as keys for building and sustaining the confidence and motivation necessary for success in STEM (2013). Graham and his colleagues tap into Bandura's (1989) development of self-efficacy, a person's belief or sense of agency to be successful in a given pursuit, in building their framework, in which student confidence and motivation are manifested in the student persisting (in this case, in a STEM field).

Similarly, Drew (2008) draws on the prior success of teachers, mentors, and peer and tutor-directed workshops – overt forms of social capital, especially in the discussion of the famous Treisman calculus workshop approach, demonstrated to significantly increase the success of potentially at-risk students in a challenging math course – to vastly improve student achievement as well as student interest and windows of future opportunities, the very factors

highlighted nearly two decades before by Oakes (1990a). Hrabowski's ground-breaking work with the University of Maryland, Baltimore County's Meyerhoff Scholars Program echoes the importance of mentoring, a coherent learning community of scholars, and early research experiences as crucial to STEM persistence for Latino students and others from racial and ethnic groups historically underrepresented in science (Summers & Hrabowski III, 2006).

On a larger scale, California's Mathematics, Engineering, Science Achievement (MESA) program has found great success over the past four decades helping Latinos (mostly Mexican Americans) and other students underrepresented in STEM to explore and succeed in science and engineering careers (Somerton, 1994). MESA's work, more than any other efforts to improve science education for Latinos, has been brought to impressive scale. MESA achieves its success through an integrated, highly organized pre-college and college program with academic and career advising, industrial trips and internships, workshops and tutoring, scholarships, contests and science fairs, and an overall balance of nurturing young people while pushing them far beyond what they otherwise might have thought possible (Somerton, 1994).

Another helpful approach to persistence, while not explicitly linked to social and cultural capital, lies in resilience theory. Bonnie Benard operationalizes the idea of resilience as rooted in the interaction of personal, family, community, and school-based protective factors that can help individuals facing many risk factors to ultimately succeed in becoming successful members of society (1991). Her construct of resilience theory synthesizes four decades of research on factors that lead individuals to succumb to, or conversely, overcome various stressors or risk factors, from poverty to trauma, from early health problems to language difficulties, to facing racism and other inequalities. She offers a profile of what resilient children or adolescents look like, from the perspective of each type of protective factor, or personal or environmental

characteristic. Resilient individuals demonstrate strong personal tendencies toward persistence, optimism for the future, goal-directedness, high educational aspirations, "coherence" or confidence, healthy expectations, achievement motivation, and success orientation. While these seem to be the most universal personal attributes of resilient children, Benard also notes that many studies have added such traits as autonomy, problem-solving skills, sense of purpose, and social competence. All of these internal characteristics seem to be fed by a variety of external, environmental factors (Benard, 1991).

At the family level, close bonds with a caregiver (usually, but not always a parent), high expectations, and encouragement of participation or responsibility from a young age seem to be important; however, subsequent empirical work that will be reviewed suggests that even without these family-level factors, resilience is still possible, albeit through extra-familial environmental factors. Benard recognizes a number of these factors at the school and broader community levels. Starting at the school level, caring and supportive relationships with at least one adult seem to be key, which falls in line with the distributed counseling and advisory models utilized by many small, progressive public schools today. High expectations and opportunities for engagement and active participation within classrooms are also noted as keys to resilience. Finally, at the community level, these same strands of supportive, caring relationships alongside high expectations and diverse opportunities for engaging and participating in meaningful activities are tied to the facilitation of developing resilient children and teens (Benard, 1991). As an extension of Benard's discussion, it seems from her model that while family support is ideally at the heart of fostering resilience, it is ultimately the presence of support and caring from older mentors, high expectations, and opportunities for engagement in meaningful tasks. Ideally, this is the case at multiple points along the dimension of social and psychological distance from the

nuclear family unit outward to the local community and beyond, that can sustain the personal traits necessary for long-term resilience and success.

McMillan and Reed (1994) offer a more recent conceptualization of resilience, echoing while also extending the protective factors identified by Benard. Their review of prior empirical studies of resilience garners a more specific, "tighter" set of protective factors or themes that are highly associated with resilient, at-risk youth. Included among these are positive attitude and reciprocity, a strong internal locus of control, optimism, self-efficacy, required helpfulness (an alternate rendition of Benard's idea of participation and responsibility), realistic goal-setting, and caregiver support (McMillan & Reed, 1994).

Much of the empirical evidence for Benard's resilience claims comes from the seminal work of Werner and Smith, who conducted a comprehensive, decades-long longitudinal study of every individual born on the island of Kauai, Hawaii, in the year 1955. Key traits found to describe resilient individuals included internalization of a structured set of values, belief in the value of their efforts (analogous to achievement motivation and self-efficacy), internal locus of control, a strong sense for finding role models and mentors (an extension of Benard's social competence), and an ability to develop and rely on a strong network of peer and adult support (Werner & Smith, 1989). One can further infer from Werner and Smith's descriptions of the positive coping skills developed by the resilient adolescents and young adults in their study and prior studies that challenging experiences with poverty and other issues were ultimately beneficial to these individuals, acting as a kind of necessary adversity (1989).

While limited by their lack of a control or comparison group, and often by small sample size, these recent qualitative investigations are still invaluable in contextualizing resilience in specific settings for particular groups of at-risk individuals; their ethnographic and grounded-

theory approaches to data collection provide thick description to build a more comprehensive resilience "milieu" beyond that which is often possible from large-scale, quantitative studies. Morales's 2000 case study, and 2008 follow-up analysis, of five resilient Dominican students at New York University who have overcome economic struggles, and in some cases familial instability and/or poor early educational opportunities, to matriculate and succeed at a highly selective university provides an example of this. While the very small number of students profiled (just two of five in the original study, and four of five in the follow-up, with the fifth student "disappearing" before the follow-up) limits the scalability and overall external validity of the study, Morales (2000, 2008) poignantly extends Benard's notion of caring and support in the context of the mentors and role models who sustained these NYU students in the face of myriad obstacles. Likewise, Floyd's (1996) study of twenty African American high school seniors in urban schools contextualizes the qualities of persistence and optimism, and of support of parents and other caring adults in the community, in a time and place beyond that which was available in Werner and Smith's study of ethnically diverse, rural Kauai youth.

Reynoso's (2008) study of resilient Dominican English language learner young adults at an urban community college added another unique context to the fray of resilience research. While his definition for resilience seemed to be broad and could have been better defined, and his sample (which included just six students) could have been expanded for greater external validity, his study did demonstrate the value of multi-level faculty, staff, and peer support for a uniquely disadvantaged group of students that is often under-served by educational institutions (Reynoso, 2008).

Morales (2010) also conducted a larger scale study, of fifty low-income students of color, that extended from the focus of prior work on simply identifying protective factors, to actually

linking protecting factors and isolating linkages among different factors, finding that some factors seemed to work together in symbiotic clusters, exerting a great total positive force than the sum of each contributing factor. Key to this study was a careful analysis of the importance of school-based mentors who acted as cultural translators and as mediators (or, one could argue, co-constructors) of a strong future orientation with their mentees (Morales, 2010).

Suarez-Orozco, Pimentel, and Martin's (2009) longitudinal investigation of newly arrived immigrant adolescents (including those across the spectrum of resilience and success) was far more comprehensive and conducted from a social as well as psychological perspective, highlighting the importance of school context on top of factors previously delineated by Benard and others as important for those who succeeded. Their thoughtful discussion of previously studied protective factors and risk factors was quite comprehensive and informed their large-scale study quite well. Suarez-Orozco et al's study measured students' experience with school and neighborhood violence and bullying, academic self-efficacy, cognitive as well as behavioral measures of engagement, and students' relationships with adults in school and at home, and the relationships of these variables with students' academic achievement trajectories. Loving family relationships, supportive relationships with teachers or other school staff, and helpful peers who shared the same cultural background all correlated with student engagement and success in school, even in the face of economic and linguistic barriers. High expectations from the family, previously raised by Benard, were also associated with success, as were safe, non-threatening school environments. Suarez-Orozco et al (2009) concluded that all schools with students like those in the study must strive to provide an environment rich in supportive relationships, with teachers and other staff exerting a nurturing influence as mentors and cultural and academic guides, similar to the aforementioned suggestion of Morales (2010).

Likewise, Gonzalez and Padilla's (1997) tight, carefully constructed study of resilience among low-income Mexican American high school students concisely outlined supportive academic environments and sense of belonging in school as being statistically significant contributors to resilience for the small minority of students who met their rigorous definition of resilient. This study employed an extensive questionnaire of over 300 items exploring such variables as peer values and conformity, self-esteem, maturity, life events that could act as stressors, relationships with teachers, and ethnic identity, with the items ultimately collapsed into sub-categories within the domains of support (from the home and school), sense of belonging in school, and cultural loyalty. Resilient students reported significantly greater senses of support and belonging, at the 99.99% confidence level, and sense of belonging was shown by regression analysis to predict student grades, suggesting that schools strive to create environments where students feel close ties with others at school and value their schooling experience (Gonzalez & Padilla, 1997).

While the body of research specifically referring to Latino/a or urban immigrant ELLs in science education is relatively limited, a recent volume edited by Sunal, Sunal, and Wright (2010) makes an impressive dent, supporting prior work done with ELLs and Latinos in and beyond science education, and also supporting research with other frequently marginalized urban students. In terms of improving students' awareness and aspirations toward postsecondary STEM study, a program developed to leverage and build social capital through language-infused, high-interest science teaching, coupled with college access guidance and an enrichment rather than remediation framework, was demonstrated to show great benefits to an open-access group of Latino ELLs (Musetti & Tolbert, 2010). Peer mentoring, high levels of nurturing or personal attention (as with MESA), and collaboration were also hallmarks of the work (Musetti & Tolbert,

2010). A strong sense of community and collaboration connecting students and teachers across race, class, gender, and language differences was also recognized by Conchas (2009), specifically as expressed in a within-school academy uniting students through a professional interest in health care, a key sector of STEM careers. In the Rio Grande Valley region of southern Texas, a region predominantly populated by low-income Latinos, two districts have extended this work in offering Early College academies to all students and building a culture of simultaneous high expectations and high support that extends to parent programming, mentoring, and other constructive out-of-school-time, all embedded in building a college-going culture (OST) (Nodine, 2010; Smith, G., personal communications, March 29 and April 17, 2013).

With regard to specific teaching practices, Musetti and Tolbert's (2010) chapter, as well as that of Johnson (2010), emphasized the importance of critically situated, culturally relevant pedagogy capitalizing on students' funds of knowledge that they bring with them from their home cultures, languages, and communities (Basu & Barton, 2007; Kincheloe & Steinberg, 1998; Ladson-Billings, 1995). Beyond the usual valuing of students' strengths as defined by a critical approach to pedagogy, teaching urban immigrant ELLs, Latino or otherwise, also involves paying explicit attention to the cognitive academic language proficiency in science that students must develop over time in order to communicate and also incorporate new ideas learned in their newly acquired language into schema that they have built up (Musetti & Tolbert, 2010).

The presence and quality of supportive relationships, ideally with more than one person and at more than one level (parent, other family, school staff, and other community members), cannot be overstated between youth who are dealing with various challenges and adults who can act as powerful motivational agents and mentors. In a time when the United States continues to struggle with equal access to high-quality educational opportunities, and is faced with vast

shortages of well-trained individuals in STEM (science, technology, engineering, and mathematics) careers, in particular, it would seem fruitful to conduct research, including empirical studies, focusing on resilience and persistence within the so-called STEM career pipeline. Since these are fields known to have massive barriers to entry based on the culture of the disciplines and rigor required for successful study (which have an unfortunately proud tradition of "weeding out" many motivated, able students), investigations of how students facing multiple disadvantages can "make it" in these areas of study could contribute greatly to scholarship and advocacy for access and persistence within these rewarding and lucrative fields.

Until the present, research in this area has focused predominantly on helping more students of color to be successful in STEM majors through specific types of support in college. With the notable exception of MESA's systematic work at the high school level, most of the framework for the present study has come, out of necessity, from intervention strategies and programming at the college level. Many other potentially high-impact programs, from federally-funded GEAR UP and Upward Bound programs to private and community-based programs like Sponsors for Educational Opportunity, are essentially unavailable to immigrant English language learners who arrive in the US as teens (i.e. the focus of this entire dissertation study), with some programs even telling the researcher that they hesitate to work with recently arrived immigrant ELL students due to their language skills.

Lisa Tsui (2007) offers a comprehensive research synthesis delineating key prominent components of successful programs for boosting underrepresented minority student success in college. She notes the importance of students gaining a strong foundation in mathematics and science before college and of exposure to science and mathematics-related activities and advising. From all of the college-level intervention programs that she reviews, the most

prominent elements consist of summer bridge programming, mentoring from professionals or older peers, early research experience, financial support, a program-focused or other science/math learning center, effective tutoring, and comprehensive personal, career, and academic advising and counseling. Maton, Hrabowski III, & Schmitt's (2000) evaluation of the success of the Meyerhoff Scholars program largely aligns with Tsui's program components, but also adds the importance of a sense of community, study groups, and community service as elements that further contribute to student success. Together, all of these elements are considered against the backdrop of the persistence, resilience, and capital frameworks in the development of the study materials and methods as described in the following chapter.

Chapter 3

METHODOLOGY

Research Design

The proposed investigation is rooted in the social and cultural capital theories of Bourdieu, Coleman, and Lareau, as situated within the persistence framework of Graham et al, and complemented by Benard's conception of resilience. Student experiences are approached and interpreted through the lens of community and social structures and institutions, with explicit attention paid to students' race and ethnicity, class background, neighborhood, and high school context.

The overall dissertation project, based on the research questions, purpose, and background delineated earlier, comprises the following phases, or sub-projects:

(i) In-depth, ethnographic case study of four urban immigrant ELLs (with a declared interest in STEM at end of high school) from "BELL HS" over a 6-year period from arrival in the US through 3rd year of college

(ii) Ethnographic case study (with larger grain size) of thirty-seven urban immigrant ELLs with a declared interest in STEM at end of high school (27 STEM "persisters" and 10 STEM "switchers") from BELL HS over a three-to-seven-year period from arrival in the US into their college careers

(iii) Descriptive/analytic study of ten urban immigrant college students with a declared interest in STEM at end of high school who are part of access programs at a comprehensive public liberal arts college that recently committed to making attempts to serve urban immigrant ELLs

A case study approach is at the methodological heart of the project, especially the first sub-project, because thick description and analysis of student experiences was desired, especially with little prior work detailing the experiences and trajectories of urban immigrant ELLs in this academic milieu (Stake, 1995). A collective instrumental case study approach is fitting since one of the overarching goals of the project is to understand and document the issues and challenges faced by a particular group of students, as well as the ways that members of the group have been able to succeed past these challenges (Creswell, 2013). The cases will be analyzed with a critical ethnographic lens, an approach previously implemented by Barton and Yang in a case study unpacking issues of power and culture that can threaten engagement and remove individuals from marginalized groups from persisting in their entry to STEM-related fields (2000).

Such a framing would be suitable because the research requires a deconstruction of student experiences, and consequent inquiries into these experiences, as the researcher had in-depth access to the informants and various aspects of their social worlds (in particular in phases i and ii) over a period of multiple years (Gaskins, Miller, & Corsaro, 1992; Madison, 2005). Further, critical ethnography's roots lie in exposing and questioning inequalities in social structures, and the approach permits analysis and searching for ways to transform and change the nature of these inequalities. In critical ethnographic work, the rich descriptions and analyses of the participants' experiences and social worlds offer significant empowering and emancipatory potential with respect to the marginalized group under investigation by calling for and working toward the altering of common or dominant practices, or *praxis* (Tan et al, 2012; Trueba, 1999).

In addition to qualitative information, phase ii includes a variety of descriptive statistics to help in further depicting this unique group of STEM persisters who, on paper, are demonstrated to fall outside of what prior researchers, and the prevailing status quo in the world

of college admissions and academics, consider as legitimate contenders for STEM majors (or, often, any major) at a four-year college. Comparisons with the ten students from phase ii who left STEM fields (STEM "switchers") will allow for more of a true mixed-methods analysis, with descriptions of student experiences at the secondary and post-secondary level alongside a case-control study design, a type of retrospective quasi-experimental study with the two groups divided by a binary outcome, in this case, persistence or attrition from a STEM major and switchers (Shadish, Cook, & Campbell, 2002).

Logistic regression is the most suitable quantitative analysis method here because, as part of the case-control design, the dependent (outcome) variable is binary – STEM persister or non-persister (switchers) – and the relative importance, or weights, of various categorical as well as continuous numerical input (independent) variables (Analysis of Case-Control Studies, 2015); unfortunately, due to the relatively small number of accessible students who meet the study criteria, quantitative analysis will be limited to simple inferential statistics such as t-tests and ANOVA analyses alongside the rich set of descriptive statistics available. Finally, the third phase aims to extend the external validity of the work from the limited recruitment setting of the first two sub-projects, expanding the field of study beyond the unique school setting and over-age ELL population represented by BELL HS. It relies on semi-structured interviews administered on a college campus. The original plan was for the students from phase ii to be compared with the STEM switchers and persisters from phase iii, as a way of providing some way of comparing the unique group of persisters of sub-project ii with students who face at least mostly similar challenges, thus providing some means for comparison and potential grounds for generalizability beyond the BELL setting; unfortunately, a change in that university's administrative liaison to this project led to an unexpected change in access to the university's

students, such that no STEM switchers were found, and only ten persisters agreed to be part of the study. Consequently, phase iii data are ultimately being used more to complement the findings from in the central part of the study, phase ii, rather than serve as a distinct phase with sufficient data for a separate analysis.

In sum, the entire project may be considered a multiphase transformative convergent mixed methods study (Creswell, 2014). The first phase, sub-project i, is a critically situated qualitative study that offers the richest, in-depth description of student experiences. The preliminary findings of this first phase lead to the design and focus of the second phase, expanding to include all BELL graduates who are pursuing a four-year college degree in a STEM-related field. A critical ethnographic eye is maintained in this phase, as the researcher has been similarly engaged in observing these young adults' in and out-of-school communities and lives over a multi-year period. The larger number of students in this phase, however, also makes it possible to observe trends across a larger portion of this population of urban immigrant ELLs pursuing STEM careers at a four-year college (who would not be widely considered as legitimate candidates for 4-year STEM programs by most college admissions officers and researchers at the time of high school graduation), thus lending itself toward quantitative data and the transformation of some qualitative data into categorical data that can be analyzed quantitatively (e.g. by frequency across the sample).

Overall, the strength of the design lies in the qualitative data offering more of a close-up, in-depth study of student experience, while the transformation to quantitative data allows for greater generalization and comparison to the greater population of urban immigrant ELLs. Furthermore, this phase includes the entire population of BELL alumni meeting study criteria. The researcher posits that this group represents a group that likely does not have a very large

number of non-BELL-alumni members, based on his professional engagement, observations, and discussions in college access over the past three years, from college admissions and college opportunity/access programs (special college admissions and support programs specifically designed for low-income students) to college advisors at schools within BELL's network, serving large numbers of urban immigrant ELL students.

Like prior researchers and practitioners, the college admissions and even opportunity program staff members tend to view students with SAT scores in the range of BELL's stronger students to be well below the threshold for admitting students and investing in their success, especially in demanding STEM-related fields that already face high attrition rates (Seymour & Hewitt, 1997; Maton et al, 2000). College advisors at other schools serving large numbers of similar students, albeit regular-aged rather than BELL's over-age population, as well as BELL's principal (a former social worker and principal at two similar schools), have noted the rarity that these students go on to a four-year college to study anything, let alone STEM, unless they have test scores that are generally far above those of BELL's strongest students (which are usually just 400-500 in mathematics and 330-400 in reading). While it seems likely that very few students with profiles like those of BELL students "on paper," in terms of the test scores and high school course offerings that are used in college admissions, matriculate directly to four-year colleges for any major, let alone STEM, the direction and philosophy of the admissions and student support staffs of "U-State," as introduced below, provide some semblance of comparison students among their STEM major persisters and switchers.

By investigating the pre-college STEM trajectories, experiences, and relationships of the BELL students over a multi-year period, and comparing this information and their academic performance in high school and college with those from the comparison group at U-State (who

generally started learning English at a younger age, likely have somewhat higher test scores, and often had access to more advanced courses than BELL students), one can gain insights into the key influences and factors that are helping the unlikely BELL alumni (seemingly unlikely in their quest to even graduate from high school, and then to attend and succeed at a 4-year college) to succeed in their path toward a STEM career. In the absence of a population large enough to employ logistic regression, simple inferential statistics such as t-tests will help to demonstrate where significant differences existed between STEM persisters and switchers along various markers of academic performance, educational background, and pre-college experience factors. Descriptive statistics of student rating of STEM pre-college factors' influence on their futures will also be considered. All of these potential influences will be further unpacked, in a more complex manner than can be done by simply converting student experiences into binaries (e.g. participation or non-participation in a given pre-college program or with a given type of mentor), especially with the sustained period of observation that the researcher has had with the students, which further contextualizes even their questionnaire and survey responses.

Setting and Participants

The students in phases (i) and (ii) are urban immigrant English language learner young adults who graduated from BELL High School, an urban public school focused explicitly on serving the academic and socio-emotional needs of 16-21 year-old immigrant youths who are English language learners. The school is located within a couple miles of neighborhoods of concentrated wealth, but is also adjacent to and partly surrounded by chronically economically depressed urban neighborhoods, including some of the poorest in the United States. Ninety-five percent of the school's students had incomes low enough to receive free or partially subsidized school lunches, and over 99% of the student body comes from developing countries, primarily in

Latin America and West Africa. Students live predominantly in the poor and working-class neighborhoods within a few miles of the school. The researcher has lived in one of these neighborhoods since BELL's founding and has also spent considerable time in this and other student neighborhoods over the past six years, including but not limited to library study sessions, home visits, and exploring these areas so as to have a better understanding of the neighborhood environments.

Students arrive at the school with between zero and twelve years of prior education, and with limited, if any, functional English proficiency. While the school enrolls students with a wide variety of academic and linguistic skills, the average BELL admit is 17 years old, speaks no English, and has academic skills in the native language around the 3rd-4th grade, based on estimates from teachers and other staff members. Many students enroll with an interrupted or otherwise limited formal educational background (often known as SIFE, or students with interrupted formal education), and the school loses a significant portion of its students prior to graduation, which requires passing several state exams. Less than 30% of BELL students consistently attended school full-time throughout their childhood and adolescent years prior to arrival in the US, and at BELL. BELL students' average SAT scores are among the lowest of any high school in the state, with median scores in the low to mid-300s for both mathematics and critical reading.

As of summer 2015, the four BELL alumni in phase (i) ranged in age from twenty-three through twenty-seven, including one male and three females. All four are upperclassmen at four-year colleges in the northeast. The students were all newly arrived immigrants upon enrollment at BELL in 2008 or 2009 and were part of the school's inaugural graduating class. One student each was from the Dominican Republic, El Salvador, Guinea, and Senegal. The two Latina

students speak English as their second language. The two West African students speak English as their fourth or fifth language. The four students' families reside in the Bronx and northern Manhattan, and they come from low-income families. Students were selected as instrumental cases for the study as Bell students who overcame significant obstacles en route to developing passions for pursuing STEM careers, and becoming very strong students at Bell. The fabric of each student's life emerged in vivid detail during the study.

Phase (ii) includes twenty-seven young adults who are pursuing a four-year degree in a STEM-related field, as well as ten who have switched from a STEM to non-STEM-related major, following their graduation from BELL. This group represents all BELL graduates who were exposed to a unique array of targeted college access counseling, STEM career counseling, and STEM outreach and enrichment programming while at BELL, and who have persisted to high school graduation and matriculation into a four-year college to pursue a STEM major. They arrived in the United States, and at BELL, between 2008 and 2013, graduated as part of the school's first four graduating classes (2012-2015), and are in college (freshman through senior year) as of December 2015, the temporal endpoint of the investigation. Their background characteristics will be described more fully in Chapter 5.

While the plan was for phase (iii) to include thirty urban immigrant ELL students from a college (referred to as "U-State") located in the same state as BELL, an administrative staff change led to difficulties with getting access to the full list of students who would be eligible for the study, such that only ten students, all STEM persisters, were interviewed. U-State College is a small, comprehensive public liberal arts college in a remote, rural setting several hours north of BELL that recently committed to making attempts to serve urban immigrant ELLs, starting with a relationship built with BELL by U-State Admissions and the researcher over the past three

years. U-State has been test-optional for several years, the only public four-year college in the state that does not require SAT scores for admission, preferring a more holistic approach of considering students' high school transcripts, state test scores, essays and recommendation letters, and other information. The college is a predominantly white institution located in a predominantly white, remote region. The researcher has spent considerable time at U-State, which is also attended by nine of the BELL alumni in phase ii, meeting and interacting with students and staff during and prior to the interviews that were an official part of the project.

U-State furnishes a highly supportive, state-funded Opportunity Program, like several dozen other institutions in their state, offering admission with generous financial, academic, and social support for low-income students whose test scores and high school records fall somewhat under those of their respective university's regular-admission standards. Additionally, both institutions offer a state-funded program aimed at supporting low-income and underrepresented minority students in STEM-related fields. Participants in phase iii are completing at least their third semester of college at the time of their participation, and most are members of an Opportunity Program and/or minority STEM access program at the college. U-State has a limited number of students who fit the study criteria as urban immigrant ELLs with relatively uncompetitive test scores, but likely a far larger number than other four-year institutions in the state based on the researcher's four years of college access experience and keeping track of Opportunity Program admissions criteria at dozens of institutions throughout the state, making U-State as good a setting as any for a comparison group of students. Eigible students were recruited for participation by opportunity/diversity program staff and by other current students (i.e. snowball sampling).

Data Collection and Analysis Methods

For sub-project (i), data was (and will continue to be) collected through the use of (a) three extensive, semi-structured group interviews, 1.5 to 3 hours each, from June and July 2012 that were videotaped and transcribed manually by the author, (b) a preliminary background survey from August 2012, (c) a follow-up questionnaire from August 2013, (d) a detailed, open-ended qualitative pilot questionnaire in November 2013, and (e) follow-up conversations in 2014 and 2015, as well as through the instruments used with these young adults in sub-project (b), of which they are also a part (see Appendices for details). The questionnaires were developed (and will continue to be developed) in light of these interviews as well as the prior sociological research of Tobias (1994) to attract and retain a wider variety of students in STEM. The data and subsequent analysis was also impacted by the seminal work of Dr. Elaine Seymour in *Talking About Leaving: Why Undergraduates Leave the Sciences* (Seymour & Hewitt, 1997; Seymour, Hunter, Thiry, & Pfund, 2014), and by conversations with Seymour. For sub-project (ii), data is being collected through questionnaires during the spring semester of 2015 and through interviews during the latter half of 2015, and for sub-project (iii), interviews in November 2015 will supplement spring-semester pilot interviews that are being used to help develop the final protocol for this final phase, the only one for which the researcher does not already have extensive knowledge and familiarity with the participating students.

Further data (for phases i and ii) was and continues to be collected from observations of and conversations with students in a variety of settings from fall 2008 through the present. These observations and interactions occurred in a variety of formal and informal, natural settings in and outside of the BELL school building. Settings included the science classroom during and after class periods and after the school day finished, summer research laboratories, libraries,

students' homes, colleges, soccer fields and other parks, cafes, and informal dinners at the researcher's home, among others. Observations and reflections were derived from these in-person interactions as well as text messages, Facebook messages, and phone calls with the students over a four-year (or longer, in some cases) period. During this six-year span of time, the researcher has been known by the students at various points as science teacher, college access counselor, research program coordinator, and advisor.

Following the initial group focus interviews for phase (i) of the research, the researcher discussed the incidence of potential themes from the interviews with a senior researcher, prior to transcription and coding. For each phase of the research, data from interviews and survey and questionnaire instruments are analyzed through open coding, with the codes considered and "sifted" through the framework provided by the prior literature and the theoretical lens that was selected, and were compared with the larger themes that arose from the original conversations with the senior researcher. Retrospective analysis and notes and the aforementioned archival observations and conversations will supplement survey, questionnaire, and interview data (as well as transcript data) to provide ample triangulation of data in the first two phases (sub-projects i and ii) of the study as the author has had in-depth access to the students as a teacher, counselor, and mentor over the previous four to six years.

Survey/questionnaire items and interview protocols for phases ii and iii are inspired by the research of Seymour & Hewitt (1997), Tobias (1994), UCLA's Higher Education Research Institute (2015), and the still-ongoing High School Longitudinal Study (Ingels, Pratt, Herget, Burns, Dever, Ottem, Rogers, Jin, & Leinwand, 2011) – the first large scale federal study studying the STEM pipeline; U.S. Department of Education. Logistic regression analyses of academic (pre-college and college STEM and general) and non-academic experiences and

background factors will aim to elucidate how students succeed in completing STEM majors despite low test scores and other risk factors, thus complementing the thick (qualitative) descriptive data of the study in order to comprehensively answer each research question using tools from multiple research perspectives.

Table 3.1
Summary Data Collection Table

Research Questions	Phase(s)	Data Collection Procedures
1. How do urban immigrant ELLs navigate success in persisting to pursue STEM careers, especially during and after the crucial transition to college period, when they may not, on paper (by test scores, etc.), be considered legitimate STEM contenders?	i, ii, iii	Small-group interviews, individual semi-structured interviews, questionnaires (qualitative), surveys (quantitative), retrospective notes, high school and college transcripts
2. How do key experiences, relationships, and protective factors impact urban immigrant ELL students' college and career plans with regard to their interest in STEM?	i, ii, iii	Small-group interviews, individual semi-structured interviews, questionnaires (qualitative), surveys (quantitative), retrospective notes
3. How does targeted STEM outreach and enrichment programming for mostly-Latino/a urban immigrant ELLs impact students' academic performance, aspirations, and motivations toward STEM fields?	ii	Questionnaires/surveys, interviews, written personal statements, retrospective notes

Elements of Rigor

In sub-projects (i) and (ii), long-term engagement with the participants during and beyond the formal confines of the data collection instruments, over a period of two-and-a-half to seven years, provided an element of rigor to the data collection. Triangulation of the aforementioned multiple data sources was used to improve reliability and internal validity, including the trustworthiness and credibility, of the data collected, with the potential weaknesses

of any one instrument or method of data collection being offset by the strengths of others (Tashakkori & Teddlie, 1998).

The third phase (iii) and comparison of student data from phases (ii) and (iii) aims to extend the external validity of the work from the first two projects, expanding the field of study beyond the unique school setting and population represented by BELL HS. As mentioned, instrument items will be drawn from prior sociocultural research of Seymour & Hewitt (1997), Tobias (1994), and others for understanding STEM persistence and resilience, with descriptive statistics and inferential statistics (namely, logistic regression analyses of protective factors, experiences, special program components, etc.) complementing the aforementioned qualitative analysis. Items from prior instruments were modified, and new items and questions were devised from the framework and prior research, with an understanding that the interviews – the predominant data collection method for all phases of the study – involve individuals with their own unique context that may not be captured entirely by prior instruments; on the other hand, the building upon and use of items that have already been used and vetted allows for more focused data collection, improved validity, and a greater ability to compare with findings beyond this study, as well as greater validity and reliability with respect to the quantitative aspects of the study (Tashakkori & Teddlie, 1998).

Member-checking, by sharing and discussing intermediate data findings with some student participants, will be used across the studies when possible to optimize reliability of the data (Creswell, 2013). Furthermore, while all students, high school and college, will be de-identified, the thick description and personal nature of student responses and researcher observations and reflections are such that having participants, especially of projects (i) and (ii), complete member-checking will also ensure that students' privacy is respected.

In terms of the quantitative aspects of the project, case-control designs have been used to generate important causal hypotheses in recent decades, although the lack of a control group (and inherent lack of randomization) and ability to perfectly match case and control group members is a recognized limitation in this study. While the resulting logistic regression data will be helpful to suggest causal linkages between a variety of factual and experiential variables, the design, like most case-control studies, has limited ability to rigorously test these causal hypotheses (Shadish et al, 2002). The case-control design is being used to have some means of quantifying the potential predictive impact of mentoring relationships, pre-college enrichment and outreach activities, and pre-college STEM coursework exposure, performance, and experience for STEM persisters whose test scores, language skills, and high school course offerings preclude them from consideration as legitimate 4-year college students, let alone as 4-year STEM degree contenders. This involves the conversion of a variety of qualitative information to categorical variables, and the researcher also recognizes that this data transformation can and often does result in the obscuring of key information.

Larger-scale studies such as the federal HSLS:09 study, some items from which were used or adapted for use in this study, tend to code student participation in or exposure to a given type of experience or activity as a binary; however, it is obvious that the impact of a research or enrichment experience or mentoring relationship is far more complex than simply existing or not existing. For this reason, with a variety of complex relationships and experiences interacting within students' lives, the researcher chose the mixed-methods design, with the qualitative findings drawing out the complexity obscured by simple binaries. Naturally, this study is far smaller in its sample size than a federally commissioned study, but with a total sample of sixty individuals between phases (ii) and (iii) of the study, the researcher hopes for far greater external

validity than can be achieved with solely qualitative data with a few descriptive statistics about a smaller sample of students. The larger number of students makes logistic regression analyses possible and also allows for some added quantification (e.g. by frequency counts) of aspects of student experience that would be challenging with just a few students. Furthermore, while the researcher's prolonged engagement with students – helpful for critical ethnography – results in challenges to objectivity that will be addressed below, the exposure and observations of students (for phase ii) over a period of years does allow for contextualization and verification of students' responses regarding pre-college experiences in a way that is not often possible to researchers.

Expected Limitations and Contributions of the Research

Even with the aforementioned "checks" as well as multiple data sources planned for optimal triangulation of the results, a number of potential challenges are anticipated. Having "gone native" at times as an ethnographer who has become friends with the student informants presents one challenge, as does the struggle for the researcher to separate himself from the data and interventions at times if he is explicitly referred to in the role of mentor or advisor (Tedlock, 1991).

The emancipatory potential of critical ethnography and culture sharing that follows from the in-depth, prolonged exposure may offset some concerns over how these struggles could impact the data. The researcher recognizes that objectivity is not a precondition for high-quality qualitative research, and that "bias" can be a productive component of the researcher's perspective, a concern remains with regard to the quantitative analysis of various factors, experiences, and program components in their association with student persistence outcomes.

Another potential limitation in the research is that the researcher, in many ways, was an active co-constructor of students' experiences and coordinated a number of the programs

discussed in interviews. The relationships built with the participants, especially following phase i and ii students' graduation from BELL (i.e. the time building up to final interviews), were such that the researcher often felt like a part of the students' own communities, which he recognizes may be a source of bias. He became immersed in conversations and time spent with the student participants, and at times their family and friends, outside of explicitly planned interviews, questionnaires, and observation times. This can potentially color the researcher's interpretations of student experiences, but as a critical ethnographer engaged in work with emancipatory potential, the extra time spent and dialogue exchanged with students further augmented the culture-sharing that would contribute to the ethnographic perspective taken, and arguably the authenticity of the data that was collected, and the depth of information that students would feel comfortable sharing.

A related limitation was that the researcher was referred to directly at times in students' responses in interviews or other data collection instruments, especially in the role of mentor and teacher, and this complicated the researcher's ability to retain some level of objectivity in reporting observations and thematic responses of the student participants. On the other hand, a recognition and clarification of bias is key to the particularity of good qualitative research, and ethnographers would argue that true objectivity is not sought-after, or even possible, anyway (Schensul, Schensul, & LeCompte, 1999; Tashakkori & Teddlie, 1998).

This bias related to the researcher as observer and active co-constructor of experience could become more problematic with the quantitative, case-control analysis parts of the study. Beyond the aforementioned objectivity issues that are far more problematic in quantitative studies with their positivist or post-positivist leanings (such as obsequiousness, expectation, and recall biases), there are also potential concerns that must be discussed regarding the choice of

case and control groups for analysis (Shadish et al, 2002). The "case" of interest in this study is STEM persisters in a transformative context, focusing on individuals who have succeeded despite a barrage of challenges associated with being an urban immigrant English language learner who attended a high school with limited course offerings and low test scores. As high schools – and certainly under-resourced inner-city schools – do not tend to keep track of their alumni, and as BELL is unique in serving specifically *older,* 16-21 year-old immigrant ELLs regardless of prior education, finding perfectly matched controls was not possible.

Furthermore, of other high schools in the same city as BELL that serve high numbers of recently arrived ELL students from regions (i.e. predominantly Latin America, Caribbean, and sub-Saharan West Africa) and with educational backgrounds similar to BELL students, graduates with academic profiles similar to those of the BELL students in this study generally matriculate to local community colleges (many of which have 3-year graduation rates around 10%) and not to four-year institutions. Choosing other alumni from BELL as controls is also not advisable because BELL alumni not in this study generally graduated with future interests outside or STEM and/or matriculated to two-year colleges. The size of the STEM switchers group from BELL is relatively small, with wildly contrasting experiences and push-and-pull factors that led to their switching decisions. Their experiences will provide extra context in the study, but they may not comprise a sufficiently substantial control group for rigorous quantitative analysis.

The plan was for a control group chosen to consist of phase (iii) students who are STEM switchers attending the regional university described above, but ultimately the university was only able to direct the researcher to persisters, whose experiences will serve to extend the results from the BELL persisters at times. These students are meant to serve as a reasonable, albeit not precisely matched, group parallel to the phase (ii) persisters around whom the study is centered,

to provide some external validity, expanding the study beyond the unique environment of BELL and its small network of alumni. There are, of course, some differences between the phase (iii) and central phase (ii) students, in terms of age of immigration, resources and dynamics of the neighborhoods, schools, and communities in which they grew up, and some other factors. While as in most case-control studies, there was not one uniformly administered "treatment," but rather an interplay of various factors, programs, and relationships (several of which were coordinated for BELL alumni during their time at the school), it may be difficult to unravel the interaction of impacts of various interwoven mentoring relationships and enrichment/outreach program offerings to BELL alumni that were entirely absent, at least in this organized, cohesive format, to the comparison students. (This is one of the potential strengths of including persisters in phase (iii), as they did not experience any of the researcher's STEM enrichment or outreach programs at BELL.)

Because of college admissions policies and students' own high school experiences, it is very difficult for immigrant ELLs without very strong prior educations who arrive in the US as older teens to be accepted (with sufficient scholarship/grant aid) and matriculate at four-year colleges without considerable planning, relationship-building, and carefully targeted college access advising and management that fall outside the responsibilities, abilities, or schedules of urban school staff members. While this makes the BELL alumni an especially intriguing group to study, it confounds the possibility of having control groups for comparison. The college campus chosen for phase (iii) seems likely to contain a disproportionate share of the state's urban immigrant ELLs on college campuses based on the researcher's observations and interactions with their admissions and access program staff, but this may threaten validity in comparisons

with BELL alumni at colleges with climates less friendly to these populations (with college climate falling outside of the scope of the primary variables under consideration in this study).

Additionally, random sampling was not possible due to (a) the small size of eligible students at each campus and (b) difficulties with the researcher's college staff contacts identifying exclusively students who would be eligible for the study. At the institution that has become especially amenable to urban ELL students in recent years, starting with a relationship built between admissions and opportunity program staff and BELL, a combination of snowball and convenience sampling was used, with an oversampling of persisters because the college has difficulty identifying non-persisters (switchers) from their file system.

The researcher recognizes and anticipates the limitations inherent in this study, but the investigation nonetheless contends to produce invaluable new understandings of how multiply marginalized young adults (i.e. as ELLs, immigrants, older-than-typical students, low-income students, and members of underrepresented groups) can succeed in STEM careers. The researcher has been engrossed in this work and the lives of the BELL alumni who are presented here over a very long period of time. He has watched and at times worked to engage in their growth from teenagers with just a few weeks in their new country, sometimes experiencing consistent, full-time schooling for the first time, to their participation in various programs and special courses, to their application and admission with full-tuition scholarship/grant funding to colleges, and ultimately to their success in STEM-related fields in college.

Ethnographers tend to focus on a small, discrete, culture-sharing group and vividly share their experiences with the world, while quantitative researchers tend to prefer minimal engagement but with a far larger number of participants. This investigation offers a middle ground, with lively ethnographic detail of dozens of young people's lives, many over a span of

three to six years, unpacking their success and their understanding of it against a backdrop of the majority of well-respected universities that want to improve campus diversity but view these students as too great a risk. The students' own words and experiences, combined with the researcher's observations and engagement with the students' friends, families, and communities, provides context that will amplify the study's quantitative findings of key relationships, exposures, and experiences in a way that would be nearly impossible without a level of immersion into the students' lives that has made the investigation and pursuit of their success the central purpose of the researcher's professional life to date.

Much has been written about helping students who are underrepresented minorities to succeed in college, but as part of this dialogue, and colleges' own quests to diversify their own student bodies around racial lines, an iceberg of college STEM talent remains submerged, hidden out of sight and mind. Advocating for 21-year-old high school seniors with a 660-850 SAT score (math plus critical reading) – who started learning English at age 17 and whose high school does not offer Honors classes and has rarely offered so much as a true Algebra II/Trigonometry course – for admissions to competitive opportunity programs at 4-year colleges, including scholarships covering tuition and significant living expenses, is not exactly an easy sell.

Finding professional scientist mentors, external enrichment programs, and advanced science and math courses for such students – whose exposure and awareness of STEM careers generally includes having heard of doctors, nurses, and engineers, and who are still working on speaking and writing basic academic English – generates a lot of "I'm sorry" and "I don't have time" and "I don't think these students are ready." Building a targeted, data-driven college access program tailored to the needs of students whom most average and above-average colleges will just reject anyway may not seem like the best use of time, and activities like this or midnight

conversations to college admissions staff or hawkish, obsessive checks and updates to progress-to-high-school-graduation spreadsheets may seem disconnected from any aims related to STEM persistence, especially at a high school that struggles mightily to one day graduate the majority of the unassuming teens who walk through its doors.

Pursuing the study of persistence in STEM at the college level for students from such a setting may seem, at the outset, like an inefficient search for outliers, just as setting up classes and programs for students to engage in STEM beyond the level possible in the school's classes is perhaps sometimes been thought of as a ton of energy invested in some kind of elite that the school simply does not have. If the researcher has learned anything from his interaction with the young adults who will be included in this study, it is that a belief in persisting to one's goals, of working toward a kind of resilience that may seem irrational to the outside observer, is central to effecting impactful positive change. The findings will certainly come with limitations, and the researcher cannot establish causal linkages to explain the unlikely successes of all of the BELL alumni who form the centerpiece of the study, but the project should certainly offer insights into changing the conversation of who can succeed in STEM. It will offer keen insights into the kinds of experiences, relationships, and exposures that are needed but are so often lacking for the potential future STEM professionals who need them most, and whose perspectives and contributions may well help shape the futures of their own communities as well as the broader society, especially in an age demanding expanded and novel crops of STEM professionals.

Chapter 4

THE CRITICAL ETHNOGRAPHER: EVOLUTION AND CONTEXTUALIZATION

THE ETHNOGRAPHER: EARLY CONTEXT

My passions have shifted over the past decade from wanting to improve the world through elucidating the structures of novel molecules, as a chemist, to striving to elucidate the organic factors and dynamics that impact student access and success into STEM majors and careers, with an emphasis on working to actively question and shift the opportunity structures in place. Extending from the personal experiences and motivations introduced in the first chapter, further discussion of my own trajectory and experiences will allow me to expose and explain the evolution and basis of my research, and as such, my tendencies and biases.

I grew up as a 3rd-generation Western Pennsylvanian in a more or less middle-income town near Pittsburgh. While majority Caucasian and Christian like much of the region, my hometown and school were proudly, at least in my family, known as one of the most diverse in the Pittsburgh area and beyond. Unlike most other municipalities and districts, my hometown was a place where the white working and middle classes, black working and middle classes, and South and East Asian middle classes coexisted, where a number of Hindus, Jews, Muslims, and Sikhs lived interspersed among the dominant Catholic and Christian majorities, living in the same neighborhoods and attending the same schools.

My parents and grandfather enjoyed the seeming "league of nations" that comprised my friendship group in high school. I was the only Orthodox Jew in my town in high school, but I found my own peer community among friends who shared a common interest in science and math with me. The humanities were not viewed as particularly relevant by most of us back home, with the minority of us who deeply cared about school focusing, nearly without exception,

on mathematics and science. After graduation, most students from my high school went off to either Pennsylvania's public research universities, less selective state colleges, or the local community college, with the top few percent split between flagship public universities and private universities to pursue careers in science and medicine-related fields.

As a seasoned science and "mathlete" with a couple scholarships in tow, I confidently headed off to Brandeis University's combined Bachelor's-Master's program in Chemistry en route to my long-term goal of becoming a chemistry professor and conducting research to design novel medications to treat devastating mental illnesses. Having taken nearly every AP course that my school offered, and running out of math classes after junior year, and with summer research experience that followed from randomly emailing interesting-sounding PhD chemists whom I had found on the internet, I felt like I was as well-prepared as possible. Strongly influenced by my mother's attitude of school over everything, I had committed myself early on to my studies.

I had no idea what social life meant, in college or otherwise, since hours of homework interspersed with bowls of cereal and milk, daily prayers, and conversations with my mother had long been my routine. I never went out during high school after returning home in the afternoon from school and Science Club or community service activities, save for youth group activities several times per year. I enjoyed doing math and chemistry problems and reading my physics and chemistry textbooks, and like my friends, relaxing and having fun meant something along the lines of hanging out after school in our Chemistry teacher's classroom, the place where I had discovered that I wanted to pursue a career in chemistry. As mentioned in the introduction, students around me who were very successful academically seemed to follow a uniform script,

focusing mostly on their studies, with the only unhealthy behavior I saw among them a relatively innocuous obsession with video games.

To be sure, riskier activities like smoking and using drugs existed among some teens in the community, such as inside of the consequently often-locked and guarded school bathrooms, but the students who engaged in such activities were generally not doing well in school. Many of them made it to high school graduation and some went off to some form of postsecondary education, but these were far from the social mores I observed among my academically successful peers, and certainly for the 2% of my classmates who would go on to first-tier, top-40 universities.

As such, I naïvely assumed that a more or less singular focus on academics was the norm among the kinds of high-achieving students at universities like Brandeis, and while I was excited to finally be in a place with a large number of coreligionists, I also expected enrollment to at least somewhat mirror the nation's racial and social diversity, as I had grown accustomed in high school. I had decided on Brandeis because of the stellar reputation of its science programs, the chance to truly be part of my own religious community, and a generous scholarship offer, and all three of these factors were part of many of the very positive experiences that I had there. Other interactions and observations that I would make, however, would be transformational in my own world view and subsequent career trajectory. From a book found in a chemistry building garbage bin to a newfound obsession with Facebook and its early search tools – and even a temporary suspension of search privileges – to unexpected interactions with a few professors mostly outside of the classroom, my frame of reference would start to shift, only a precursor of what would come in the twists of fate that would follow my time there.

In the early days of Facebook, the bottom part of the page showed an alphabetical list of colleges that a person's friend's attended, as well as the number of friends at each college. I somehow became obsessed with these lists and finding patterns within them once I started noticing very skewed distributions of the kinds of schools appearing on many of my friends' pages. I would later think that hanging out in late night conversations with my new college friends was keeping me, for the first time in my life, from a singular focus on my academics, at a time when I faced more challenging coursework and peers than ever before; looking back, however, my time on Facebook, and discoveries from time spent there, were also closely related to my trouble keeping up freshman year with a tough load of science and math courses.

I remember my initial confidence at my high school preparation during that first year of college, where I would eventually realize that I was taking classes alongside a lot of college sophomores from some of the nation's highest-performing public and private high schools. Mysteriously high proportions of my college friends' Facebook friends attended Ivy League colleges and other prestigious private universities, and when I tracked it back to real life, it started to dawn on me how many of my friends' parents had doctoral degrees. I had always been drawn to making meaning from numbers, and new "hobbies" emerged during my time at Brandeis that helped me to procrastinate completing from my homework – and offered a reprieve from what was sometimes an off-putting journey through the hard sciences – that included looking up zip code demographics for their hometowns using US Census FactFinder and using newspaper and state education department websites to find demographic and SAT score data for my friends' high schools.

Brandeis's average SAT score was in the mid-1300s, but prior to my informal "research" and conversations with a couple roommates, I had never realized that such scores could be the

norm, or at least close to it, for large swaths of students in some neighborhoods and schools. Then again, I started realizing that some of my hallmates and classmates did not seem to be accustomed to the kind of lifestyle, or script for success, that I had associated with getting into Brandeis. I was shocked to find students smoking marijuana regularly, among other behaviors, especially when one of them described his very affluent suburb's reputation for the highest-quality cannabis, but then I, like most teens, was not accustomed to norms outside those of the high school and community in which I grew up. I did not know how to make sense of these upper crust pot-smokers, but still found it fascinating to speak with them and other hallmates, like the insightful Dominican guy from the Bronx who seamlessly bonded with everyone and came from a high school that would have seemed like a foreign country to most of his new peers.

Overall, the numbers seemed to fit with my Facebook observations – which would eventually get my search privileges suspended by Facebook in the days when one could search for any graduating class of any high school and find the colleges attended by the majority of its class that was using Facebook – as I was finding some public high schools with 10%, or even far more, of their graduates seeming to land at schools that I knew to be top-40 schools from US News. I was incredulous at finding my sophomore roommate's private school's figure was somewhere north of 50%. On the other end of the spectrum, I had a couple friends from large New York City public high schools with graduation and SAT figures significantly lower than my own high school, low proportions of students going on to any four-year colleges, and top-40 enrollments at or below the 2-3% mark that had seemed "normal" to me. In starting to see and develop relationships with peers from such extremes, I started to realize that students' margins for error and the possible "scripts" or trajectories that could bring them success seemed

inextricably and unfairly tied to the high schools they had attended and the neighborhoods from which they came.

I continued on as a chemistry major as these numbers started to give me a sense of sociological awareness, but I was also bothered by the "weed out" culture that I observed in science lecture courses, especially those frequented by aspiring pre-medical students. I was not interested in being a doctor, but as someone who viewed science as the primary vehicle to improving the world, I saw that there were a lot of seemingly well-intentioned people around me who were growing frustrated with the sciences and the pessimistic, desperation-filled culture that seemed to surround many of the classes, often to the point of leaving for other majors, in the humanities and social sciences. As I tutored peers in chemistry, physics, and math – mostly white suburban northeasterners but also a Somali refugee – and sat in many uninspiring lectures with depressing exam averages and increasingly desensitized (and homogeneous) classmates, I started to feel incensed that so many talented, motivated young people were being turned away from the sciences, and also wondered how the students who made it through were different in their approach and prior exposure and experience than those who were "weeded out." (I choose the term "desensitized" due to a combination of the isolation from the world that seems to be preferred in the kind of dedication to laboratory research that was driven home by science faculty, and the sense I got from developing and teaching an advanced lab module to the few proud souls who had made it to be junior and senior chemistry majors who criticized my attempts to make lab lecture more entertaining and my request of reflection on a lab learning experience.)

While I was doing well in college, my sense of disillusionment continued to build. I found a new kind of mentor in the professor who chaired the Education Program, whose classes

helped me to contextualize and make sense of the inequities I was seeing. From the vast overrepresentation of upper and upper-middle class communities at elite universities to the underrepresentation of some students – I did not understand how the student body was just 2% African American when I was a freshman – to other issues in science education and education more broadly across the K-16 spectrum, I could not separate myself from the assigned course readings.

Then one day, walking out of the research lab where I was working on my thesis, I found a book in the trash bin outside, Tobias's *Revitalizing Undergraduate Science*. The book discussed some intriguing innovations of the 1970s and 1980s in response to the exclusionary culture and social reproduction tendencies of far too many science departments. I realized that the "weed-out" phenomenon had been named, even called out, by people who seemed like experts, by Tobias as well as a team that wrote a 1997 book called *Talking About Leaving*, and the seeds were planted in my mind to consider furthering this area of research long-term rather than the small-molecule crystallography work that I was completing for my thesis. I decided to complement this with a mini-thesis in education exhaustively comparing the educational backgrounds of a few cohorts of chemistry major "persisters" and "switchers" at Brandeis from data I had from being student department representative for chemistry and coordinator of the fledgling First-Year Science Peer Mentoring program. This experience, coupled with mentoring first-year science majors and my enjoyment of a weekly experience of observing science classes in a struggling Boston public high school for a semester, made me want to get some experience mentoring and supporting students to be successful in pursuing STEM careers, both in research and practice; looking back, however, I had no idea what that meant in the real world where I was applying for jobs.

THE ETHNOGRAPHER AT BELL

At 10:02pm on June 24, 2008, I received an email from a woman I had never heard of about a teaching position at a school that did not seem to exist yet. I had a series of conversations with the veteran social worker and principal who sent me the email and 106-page proposal for "BELL High School." Within ten minutes of my bus's arrival in New York City, met by this persistent principal with a dream of providing quality educational opportunities to 16 to 21-year-old newly arrived immigrant young adults who had to simultaneously learn English, I signed on as a founding member of the school's maiden voyage.

College friends had hyped up Washington Heights as an inexpensive place if I moved to New York, and in August 2008 I moved there. Less than eight months after first setting foot in The City, I had moved there, and I remember the wonder of hearing and seeing all the hustle and bustle outside that first apartment window, overlooking the busy intersection of Amsterdam Avenue at West 181st Street, and the Washington Bridge connecting the neighborhood to the South Bronx. The area had a distinct Dominican flavor, with undertones of an Orthodox Jewish neighborhood on certain blocks, but overall, there were just so many people, so many cars, and so many lights and noises. My street back home was surrounded by forests on both sides, but I was now surrounded by an expansive concrete jungle that just went on and on as far as I could see, where everything, even most of the people, seemed to move mechanically, as dense, predictable, and unaware of me as the six-story buildings surrounding us.

I remember walking into room 568 on the students' first day, September 1, 2008. A few young people were already in the room, as was the teacher who was assigned as my mentor and lead teacher. I had joined the school as part of a new Teacher Residency program started by the network of schools to which BELL belonged, committed to training new cohorts of teachers with

a given content specialty to be skillful instructors of both language and content, in keeping with the schools' model that all teachers were to explicitly work on language development within her or his content area classroom.

The first student I met upon walking in was Ramon, who like nearly everyone in the room had just immigrated to the US from the Dominican Republic and spoke Spanish. I was excited to hear that he lived in Washington Heights, across the street from one of my three friends in the neighborhood. I was not yet confident in my Spanish skills, as they had laid dormant since high school, but it quickly became apparent even that first day that I would need to put my Spanish to use if I was going to be able to connect or even communicate with anyone, let alone try to inspire them to love science. Ramon had some emerging English skills, and an air of confidence such that he tried speaking at least partly in English, but most of the students' exposure to and understanding of English was negligible. I remember sitting in my room eating lunch near a group of students that day –the cafeteria was not open, and I was curious to talk with them – and I decided with a group of mostly Dominican guys, I could talk about the one thing that I figured we all valued: baseball. We did not get too far in the conversation, as I was only in my first day of full Spanish language and Dominican culture immersion, but I felt like at least we were establishing a little common ground together, which could help me down the line to getting at discussing science content together.

While I did not quickly come to feel as integrated into the Washington Heights Jewish community, I noticed that I started feeling very at home within my new BELL family. I will never forget the reassuring pat on the back and kind words of Miguel, an 18-year-old who had once been a promising baseball prospect. The second week, one of my students had a baby, and I decided to venture to East 173rd Street after school to the family's apartment. Cristina seemed

like a driven, bright young woman who liked science, even as her brother Manuel, also at BELL, did not seem to know yet what he wanted out of the school. I really enjoyed that first home visit, meeting the baby, also named Manuel – not to be confused with teenage brother Manuel, whose own nickname roughly translated to "Baby" – and seeing Cristina and Manuel, and meeting their mom and younger sister. A former social worker herself, our principal supported counselors and teachers who wanted to engage students and families outside of school time, and these home visits started providing me with a deeper contextualization of my students' lives and backgrounds outside of school.

When walking around Washington Heights, I was keenly aware from keeping tabs on student records that 20% of my students lived in my neighborhood and plenty more came through the area to shop or to transfer from one of the five Bronx bus lines that fed into West 181st Street to the 1-train, where a number of us would wait on the platform together to go to school. I did not have much interaction with people in New York outside of BELL back then, so in this city where everyone seemed anonymous it was exciting to see someone you knew.

The lead teacher with whom I was working those first few weeks had plans to move quickly from some introductory analytical thinking lessons, from logic games like the Tower of Hanoi, through heavy quantitatively-driven physics topics. The pace slowed rather quickly as it became apparent that most students did not have much prior exposure to algebra, mastery of the Order of Operations, or in some cases even fluency with carrying out basic arithmetic operations. Consequently, teaching classical mechanics and kinematics equations, and embedding them into fun real-world projects, was not going to go forward quite as planned. We spent considerable time trying to help students with shoring up their math skills, and I watched as the lead teacher gave it his all, sharing a native language with the vast majority of the students, but still struggling

to have many students understand and internalize the physics material, even on a conceptual level.

I was not in charge of my own classes at that time, but I saw students needed help outside of class, so I decided to offer Sunday Science time in the local park in the Heights, a block from my apartment, adjacent to popular basketball courts and right next to the bridge from the parts of the Bronx where many of the students lived. Just one or two students would come, so I then moved the meetings to the Bronx Library Center, but for those who came, we had the chance to go through a few problems together one-on-one in an environment that felt a lot less like school, which also meant conversations that organically flowed into discussions of students' interests and possible future goals.

I saw that when we talked about science or math one-on-one, we had a number of students who could come to enjoy the work, and who could think analytically in the way that scientists and engineers do, albeit with some significant holes. Itching to "have fun" with math and science with students who were interested in staying after school with me, as I did not yet have the tasks of planning full curricula and days of classes by myself, I tried my hand at a science and math club, and I saw that we had a number of a students who had some interest in quantitative analytical thinking and in scientific or technological issues, which I was hoping I could mold to launch them into careers in STEM-related fields. We took a few New York Math League tests and dissected the problems together, and we started planning a Science Olympiad team, too. The other schools that competed in the New York City region tended to be far more established and better-resourced schools, many with a regional name for themselves, and I dreamt that if we really focused, perhaps we could legitimately compete, at least on some exams or some Olympiad events.

All the while that I was fascinated with finding inroads to sparking and sustaining student interest in science and math, I also noticed that what I enjoyed most was talking with these fascinating young people about their lives and their thoughts and dreams for the future. Our school counselor, the son of an early-wave Dominican immigrant and the only other staff member who lived in one of the neighborhoods populated by our students, became a close friend and mentor, as well as an intercultural ambassador of sorts for me, interpreting and explaining nuances of Dominican culture and the unique brands of Spanish spoken by our mostly Dominican students. Between his lessons and practicing daily, in and outside of class with the students – BELL was over 90% Latino/a in its opening months – I started to gain a greater sense of fluency, and the students seemed to appreciate my efforts, even or perhaps especially when I made hilarious mistakes, and a sense of reciprocity began where many students seemed to buy into my teaching them about physics and basic algebra as they vividly taught me about their prior experiences, cultural heritage, and served as my own primary language immersion "teachers."

A significant shift was signaled on a Monday in late January, the last week of BELL's first semester in existence, when the physics teacher informed the school that he was resigning immediately to tend to serious health concerns. I was not yet certified to be a lead teacher, but a bevy of thoughts ran excitedly through my head as I pondered the possibility of taking over as the primary molder of BELL science, as a department of one. My principal had a remarkable sense of faith in the people she hired, and specifically in helping them to find their strengths and work with them to utilize these strengths in the optimal manner to further the future of the students and greater school community. I was just beginning to realize this back then, and as we talked, it was apparent that she wanted me to take the torch of BELL Science and shape what students would learn that next semester, and in the years to come.

The students had been working toward learning high school-level physics, albeit mostly with great difficulty, but chemistry was my area of expertise, and even though we had no laboratory or chemistry supplies or curricular materials of any kind, my principal and I agreed that I would teach a high-interest science course through the lens of basic chemistry that spring, followed by launching a college prep-level chemistry course the following year in heterogeneous classes combining these continuing students and the new students who would start at BELL in fall 2009. Our secretary/community associate, an energetic Dominican woman from Harlem who had been helping me to feel even more at home in my new community at BELL, both at work and by having me at her large family's Christmas Eve celebration in the Bronx, understood this was a large undertaking, with the new semester one week away, so she went out and bought me a box of cookies and pastries from a kosher bakery in the neighborhood just northwest of our school. There I sat with a box of cookies at a round table in the shared Assistant Principal's office/teacher workroom, with a lot of dreams but limited time and material resources to launch a chemistry program.

The lead instructional coach was to be my mentor for the rest of the year, and she, like nearly all the people in leadership position in our network of ELL (English language learner)-focused schools and my Teaching Residency program, was a progressive, inquiry-focused former Humanities teacher who strongly emphasized language development activities in all content classrooms and generally eschewed traditional assessment techniques like exams, textbooks, or problem sets. This was especially true with regard to avoiding the likes of multiple choice questions or other homework or assessment types that resembled any emphasis on procedural skill-building, which was seen as favoring rote learning. I was unsure, always keeping in mind the kinds of experiences and work that are necessary to have a shot at success in

pursuing a STEM career – my goal for my students – but I decided to give it a try, to follow the advice of the instructional coach. I had noticed in the fall and winter that most of the students did not seem to have a positive association with math and science classes, and I certainly bought into the idea of trying to make science engaging and relevant to students' lives and prior experiences, so I gave this a try through my school's chosen emphasis on inquiry and project-based learning.

An introductory unit focused on their exploration of the scientific method, including their following it through to test their hypothesis, in small groups, on how changing a chosen variable would impact the performance of, say, a paper airplane, seemed to buoy their spirits. I think part of this stemmed from being careful to make the end product of this project accessible to as many students as possible, such that everyone, or close to it, could feel a sense of success that could serve as an entry point to building a desire to further exploring chemistry. Saying "all" students would be a bit too idealistic as a few students were pre-literate in any language and barely numerate, or had very spotty attendance due to factors varying from a baby at home to not "feeling" this new construct of full-time schooling or, in one case, having a dangerously mentally ill mother.

I struggled over the course of that spring and summer and the following year with arriving at and maintaining the level of rigor that I believed to be necessary if I were to give my students a fighting chance to keep STEM-related careers as options for their futures. I also struggled mightily with managing classes with a 10-year spread in prior academic exposure (between 0 and 11 years of prior schooling) and students who spoke several different languages, most of whom did not yet speak English or were in the so-called silent period of language acquisition. I would get help from other teachers and instructional coaches, but I often felt the

students knew best how to help me, and they seemed to enjoy giving me advice on my teaching, from telling me to be more authoritative and to stop wearing wrinkled shirts during my first semester to giving me suggestions when I would ask them orally or in a written evaluation form, or after I would apologize for losing my cool in class.

On the one hand, I continued to feel increasingly integrated into and united with the student community – or communities, I should say, as there was an increasing West African community at the school, and there were of course smaller student sub-groups and sub-cultures within (and sadly only occasionally across) ethnic and linguistic groups within the school – but on the other hand, I knew that without finding a way to build a strong culture of doing homework and extending learning beyond the school day, the students would only fall further behind their English-speaking peers locally, let alone those outside the West and South Bronx. I was appalled when I learned that elsewhere in our building, network, and neighborhoods, there were thousands of students attending schools without so much as a college-preparatory chemistry, physics, or pre-calculus course, let alone more advanced and college-level coursework. I believed that the best way to effect change was to work from within, in this case in my classroom and school, and we had established an ideal of a college-preparatory, Regents-level Chemistry class. It seemed, however, that in our school's approach to serve the whole student through the likes of narrative report cards with outcome reports and no numerical or standard letter grades, and with a student body that mostly was not accustomed to attending school for as long as a traditional US school day, let alone extending it with homework, we were not moving toward our goals of accelerating the learning of our students, already older than typical high school students and anxious to get out of high school expeditiously, one way or another.

I was excited, for BELL's second year, to be teaching a language development-heavy chemistry course, to be the first in a two-year Regents Chemistry sequence. The extended timeline was due to the Chemistry course serving as a "language" course, like all courses at BELL, where there were no standalone ESL courses, in addition to a science content course. Simply saying this was a high school science course with a significant ESL layer, or a sheltered-instruction science course, as ELL specialists would call it, however, was not quite accurate; rather, there was a need to scaffold lessons not only considering development of the four language modalities (reading, writing, speaking, and listening), but also in consideration of students' widely varying prior exposure to and interaction with science, which will be addressed further in the next chapter's discussion.

I must note that whatever pedagogical strides I made during my second year, and much of my commitment to even continue developing my craft and identity as an urban science educator, were due largely to intensive collaboration with my new mentor, an extremely talented Dominican American former economics teacher-turned-instructional coach and administrator. With a mantra to "always build character" and thoughtful actions that always backed up her words, whether in modeling a lesson, helping with a unit plan, or performing wonderous conflict-resolution triage throughout the school, she helped me to make sense of the challenges that we faced as a school – the challenges that students faced, that I faced, and that we faced together. Her suggestions and "tweaks" always seemed to be effective, and were delivered in such a way that I never felt judged, whether it was becoming more thoughtful around bringing the physical classroom environment optimally conducive or taking various steps toward balancing the school's language-heavy goals for student learning with my own drive to find ways

to deliver engaging and rigorous science content that could drive student learning of challenging high school-level quantitative physical science content.

I did not know it then, but I was getting an incredible crash course in the non-cognitive factors that could drive student success that Paul Tough highlights in *How Children Succeed* (2012) and that Werner and Smith, and more recently Angela Duckworth, had been spending their whole careers studying. On the one hand, this mentor was helping me through my struggles of developing and executing a class that would prepare students to be successful in college, albeit without structures yet in place to build a strong homework and extended-day culture (beyond our staying after school and encouraging students to complete homework and extend their learning but staying for extra help) while being accessible and engaging for students who were still unsure of whether they wanted to be in school. On the other hand, my mentor was giving me lessons in developing my own sense of grit, or resilience, and that of my students, in such a way that could be self-sustaining at this moment as well as for years to come, a lesson I would not fully reflect on until I came to analyze the very results of this dissertation study.

During that second year, I took pride in my growing confidence with the Spanish language, from conversations with students and their family members during home visits to the mini-lessons I would receive in current Dominican teenage Spanish slang (*la callehera*, or street-language, as they called it) from some of the young men in my class who reveled in seeing me use one of my new phrases in a lesson in class (even as I would sometimes learn that some of the colloquialisms had other meanings such that they may not have been fit for me to use in class). Some of the students started telling me that I should go see the Dominican Republic for myself, and I started taking on the role of an honorary Dominican, between the language and my increasingly intentional decision to live and continue living in a neighborhood with rich

Dominican culture, and now on the same block as three of my students. Two of my students were cashiers at the local Burger King, adjacent to the subway station we took to and from school, and for a little while I was running a little drop-in tutoring during their breaks, until the manager caught on and told one of them to have me stop.

On the plus side, this helped me to grow increasingly flexible and confident with teaching in different – and sometimes informal – settings, and during subsequent summers when I was teaching intensive biology and chemistry review courses, it did not seem too unnatural when, due to time and space constraints of school security as well as the students, we had meetings inside the local Target store's dining area, a local restaurant, a student's living room, and New York Public Library branches in Washington Heights and the South Bronx. When I would teach a small advanced chemistry course during ELLIS's fourth year, after I had mostly moved to doing college advising and STEM outreach work, we had Chemistry Dinner Wednesdays in my living room, where students and I rotated preparing different ethnic foods to fuel our discussions of chemistry concepts and working through problems that we did not reach in class.

I took great pride on occasions when it seemed that the vast majority of my students were really learning chemistry, whether it was working through a thermochemistry activity or presenting a project on the chemistry of art. Sometimes lessons took on a slightly more outlandish quality, like a lesson about different types of categorization and ordering, important for scientific thinking and for understanding the utility of the periodic table, by students having to determine the factor that was behind their seemingly-random new seating groups (organized by home neighborhood, which took quite some time to figure out in part because of their puzzling over how I knew who lived near who better than they did). Another example was a heavily kinesthetic mini-lesson where students would imagine themselves as individual

molecules moving and interacting with others in such a manner as to take on the behavior of gas, liquid, or solid molecules by running around randomly, walking with a partner or two, or standing alone, nearly-stationary in space, respectively.

Beyond trying to capitalize on diverse learning styles, I also tried my hand – or my voice, rather – at writing and performing covers of current hip-hop songs. At a time when my regular homework problem sets and exams – which I gave to complement the kinds of project-based assessment that predominated the rest of the school – were quite unpopular, I tried connecting with music as a review tool before exams and as another way to increase student buy-in and penetrate the ties binding my students' social fields and networks. I surely looked like a fool in my opening act, flailing my arms to point to one side of the periodic table or the other as part of my chemical bonding cover of TI's "Whatever You Like." I hoped, however, that my newest attempt at entertainment and connecting by a means where I was not as strong as my students (like my adoption of some *callehera*), would help to build students' chemistry and language skills as they had to listen and fill in missing academic vocabulary words, and hopefully remember some of the rhythms and their underlying mnemonic devices to help them remember important ideas about ionic bonding.

I did not realize until much later that the second year was when I would come the closest in terms of consistently appealing and relating broadly with the widest swath of BELL's students, as I felt we did not make some of the academic strides for which I was hoping. I have always looked back fondly at the third year of BELL High School as an example of what could be achieved in terms of students' science achievement at the ground level, the classroom level, without much attention paid to macro-level forces. Of course, the truth is always more complicated, and hindsight always sweetens the crystallization of a course of events in our

memory, but the third year marked the first time that I felt truly proud of the level of knowledge and skills that my students were developing, alongside work habits and goals that would give them broad opportunities for future success.

Determined to balance equity with excellence and to prepare students to conquer the state Chemistry exam as a team effort, jointly with my students, I designed and remodeled my new classroom, physically and culturally, and geared up for a year of hard work together with them. I worked with a team of students to cover the walls and ceiling with colorful quotes, science reference materials, vocabulary "word walls," and functional whiteboard and chalkboard paint. Some students' ceiling blackboard signature "tags" would remain years later, a couple years after their graduation, until another teacher and the custodial staff decided to revert to a more standard look. Additionally, various students took on roles as academic captains, acting as peer co-teachers in their heterogeneous small groups, or as classroom culture captains who would help maintain a positive attitude and quell distractions that would arise. Other students worked with the history teacher and me to build up a Homework Club where students had time, space, and support to work together after school, three days per week. Ultimately, these visual and structural components, like sound lesson and unit planning and my increasingly less-awkward hip-hop covers under my alternate persona as "J-Hi," helped the class to move along, but ultimately it was the recognition of the supreme importance of context, and consequently strong rapport and informal mentoring relationships with many students that was built up over months and years, that made much of it possible and made the deepest lasting impressions, on both the students and me.

The more deeply I came to know students and the more students I came to know deeply, the better informed I could be as a teacher in planning the most powerful, culturally relevant

experience for my students that I could expect to result in the greatest outcomes. Unfortunately, there were some students in my classes who I did not see very often before they decided to move on, or who were physically present but with whom I never established particularly strong ties, and others for whom there was a sense of comfort and rapport in dialogue that did not translate into the kind of academic transformation necessary to excel or, in some cases, to move toward graduation. I never solved the elusive puzzle of how to build a strong enough rapport with everyone, and as my position at BELL would evolve in the coming years, so too would the kinds of interactions I would have with different sub-groups.

Fortunately, however, as that seminal third year unfolded, I found what seemed to be mutually sustaining, beneficial ties with a good number of students that seemed to help propel them, their classmates, and me forward. I went against the grain of general practice in our school and network with regular problem sets and exams, resulting in more time-consuming homework than students had ever seen before, and looking back, most of the gains I saw in terms of students buying into my idea of science being a ticket to a great many opportunities had to do with the relationships we had developed, probably much more than the high-interest units and projects around which I tried to organize learning based on student interest in medicine, health, forensics, and other topics. The trajectories of the core of students who regularly engaged in dialogues with me and took on roles as co-teachers, whether during group work in class, during Homework Club, or even as my sub when I was out for a religious holiday, will be fleshed out in the coming chapter, from a cohesive group known as the "six-pack plus a can of Coke" that long served as my cultural ambassadors and bridge-builders to student sub-cultures to Mamady's extreme examples of leadership, time spent in dialogue with students, sometimes about science and sometimes about life, was vital.

Getting to my goals of rigor, to help students to have better chances at realizing the dreams that many had to enter medical careers or other STEM-intensive areas by their mastery of the quantitative thinking skills and – something about which I was always emphatic – the conceptual, factual, *and* procedural knowledge of chemistry, and even maintaining classroom culture norms, came down largely to context. From a few students who starting to speak up for me when a peer tried to interrupt class and blame me for something, to my next door neighbor's (also a student) father asking if I were Latino when I sat down with some snacks that I had brought them one evening, as is customary to give neighbors and friends on the Jewish holiday that occurred that day, I was elated that I had perhaps "arrived" or "made it" as an accepted member of the local Latino community. I had not yet formalized the reliance of my approach as an urban science educator to the thorough interconnectedness of cultural context, but a seed was planted through discussions following a couple of chance meetings with Dr. Christopher Emdin, who seemed to be developing a whole construct around culture and context into which my lived experiences as an educator were fitting.

Speaking of seeds, the momentum continued that spring and summer with my top ten chemistry students (of fifty-three), as I had promised the class in the winter, completing generously paid summer research internships in world-class laboratories at the likes of Columbia, New York University, and Einstein College of Medicine, including eight as part of the American Chemical Society Project SEED program, for which I had become a local coordinator. Suddenly, I also found that I was also running the had the largest SEED program in New York State. Some of the tangible benefits of working hard in science were becoming evident to students, especially with the stipend and the marked contrast of their SEED experiences with the facilities where we completed in-class experiments without a true lab space,

and without running water most of the time. In terms of the research component, it followed in some ways as a natural extension from the research policy memos that they and their classmates had completed in the spring, developing their own research questions about an aspect of the global water crisis, and then exploring their selected contaminant and its chemistry, toxicology, and societal impact in their region of interest, often activating and accessing pre-existing schema (Nassaji, 2002) based on their "funds of knowledge" (Gonzalez, Noll, & Amanti, 2006) from their home country. It was the first research paper that the students had written in their lives, in any language and in any subject, and it seemed to cultivate interest even in a number of students who had been open about not liking science or math, with one such student smiling as she surprisingly enjoyed the "research buffet," as she called it, of sources laid out on the classroom tables to help with investigating water contaminants.

Reflecting on my enjoyment of talking with students about their interests and prior experiences, and my failure to inspire more of my students, including some with whom I had a strong relationship, to want to put in the hard work to master the so-called "hard sciences" or to give them all the tools necessary to do so, I was given the opportunity by my principal to become the school's college access counselor as the first graduating class neared its BELL graduation. It was a position in which I would spend the next four-plus years, and where I would have the opportunity to try to strongly advocate for my students in building bridges to post-secondary opportunities for and with them. I became acutely aware of exactly what different four-year institutions of higher education, including state Opportunity Programs focused on admitting and supporting low-income students, were looking for, both in general and specifically for entry into specific STEM majors. At first glance, college access counseling may seem detached from being an urban science educator striving to open doors of opportunity for students, but as Musetti and

Tolbert (2010) pointed out, college access and exploration activities and conversations with students can be very significant in shaping the future trajectories of immigrant English language learner teens into the sciences.

As I pored over my own students' profiles and experiences as the college access counselor (and as BELL's longtime data specialist tracking student progress toward, and eventually past, graduation), and actively participated in SEED by recruiting scientist mentors and then working with students on their final research reports, I also started to think and learn more about other outreach and enrichment opportunities that could extend student learning past the relatively limited cadre of courses and resources offered at BELL. I would also strive to continue building mentoring relationships with students, as I enjoyed the long-term mentoring of students, especially as it related to cultivating STEM interests, and I found this type of multi-year mentoring to be sustaining to the point of feeling like a fuel source that would keep me going at times when I seemed to be running on fumes. Without the golden opportunities provided by daily interactions with students to directly influence their perceptions of science as a classroom teacher, however, I had to find new ways to meet and mentor students, and I could not rely upon doing so simply from working with them through the college process as seniors.

A few 9^{th}-10^{th} grade teachers, especially one biology teacher, became particularly instrumental in connecting me to students in whom she saw a yearning to learn more science or a science-related career interest. As had been the case when I was a classroom teacher, few things were better catalysts to action for me than conversations with students about their interests, passions, and career goals, and I came to thinking about what we could arrange outside of our regular classes to further accelerate these students' energy for science as well as their skills so as to be able to better realize the long-term goals they were considering. I excitedly dove headfirst

into the world of STEM enrichment and outreach, looking for opportunities that could benefit my students by helping them to explore STEM careers, and strengthen their skills with supplemental coursework, provide them with engaging hands-on experience, and I would find out about many of these opportunities through the new circles I had joined as a part of the college advising world.

In many cases, one door would frustratingly close, as a college or pre-college enrichment program would judge even quite strong BELL students as being too old, too limited in their language or academic skills, or otherwise inadequate; while devastating, these experiences would make my students and me even more determined to prove ourselves. Each door that slammed in our faces also furthered my resolution and dedication to this research project and its emancipatory basis, as I realized that using the tools of sound educational research, in documenting the paths of all of BELL's STEM career hopefuls through their high school and college experiences, breaking down the successes and challenges, would be a kind of proof-of-concept that students who many judged on paper as unlikely or incapable of success at a 4-year institution could, in fact, succeed, and do so in STEM fields, which often have even higher barriers to entry. I would observe time and time again that BELL students had a far lower margin for error than my own high school peers, and exponentially lower than many of my Brandeis classmates; conversely, I found that many of them, as easy as it was to write them off, continued to find ways to excel, if only given the opportunity and support to do so.

A number of key programs and partnerships that I would work on building over the years with colleges and enrichment and outreach programs will be documented in the chapters to come. Some of these programs and relationships would alter the fundamental fabric of opportunity structures that our students could traverse, and consequently reshaping the very

achievement ideologies present among hopeful BELL juniors and seniors. As in teaching, there was no one-size-fits-all approach, and as such an individualized approach was often taken such that, while some programs impacted relatively large swaths of students, other outreach programs or STEM internships only included a couple BELL students.

I would often think to myself as a teacher, and then as a counselor and program coordinator, that a lot of the efforts that my colleagues and I undertook were largely inefficient, considering the degree of growth and number of students who would grow as a result of a given type of intervention, strategy, or after-school tutoring session. No one action, whether in or outside the classroom, would engage and inspire everyone, or even a majority of students, and sometimes significant time would be dedicated by me, or one of my science or math colleagues, or one of my student leaders or "co-teachers," toward efforts that we would ultimately find to only move a few students forward. An arguably unhealthy number of my waking adult hours have focused on thinking and acting toward the cultivation of STEM talent over the long term starting with my "home" setting of BELL; as such, I struggle with presenting "just" twenty-seven students who have gained entry to and persisted to date in Baccalaureate STEM degree programs despite not "looking the part" to the maintainers of the status quo who act as gate-keepers of opportunity. Then again, my training as a researcher, first in chemistry and then in education, remind me that true progress can seem insufferably slow, such that I must maintain hope in the hard-fought gains or discoveries, albeit on a small scale, that may be brought by this study.

Chapter 5

THE STEM ASPIRANTS IN HIGH SCHOOL

This study focuses on following the trajectories of BELL students who have aspired to pursue a STEM-related degree at the Bachelor's degree or higher; in this chapter, a number of representative students will be introduced, along with descriptions of some of their formative experiences from their home countries and their time as BELL students that would shape their STEM-related interests before they went off to college. Before giving an overlay of descriptors and basic statistics of BELL students overall, and STEM "persisters" and "switchers" in particular, students from phase (i) of the study (who were also part of the more comprehensive phase (ii) and completed extensive supplemental interviews following their high school graduation, as they were about to embark on their college careers) are introduced, as it was against the backdrop of this opening phase from which the rest of the study evolved. While some differences in characteristics observed at the high school level are introduced in this chapter, ethnographic descriptions of individual students are limited here to their trajectories toward STEM while in high school, with their later trajectories (including persisting in or switching out of the STEM Bachelor's degree pipeline) to be left for further development in the following two chapters. (Note that all names given are pseudonyms.)

INTRODUCING THE ORIGINAL PHASE I STUDENTS

Mamady

Mamady fled civil war in Liberia as a small boy, was separated from his parents, and moved to Guinea. His father, who had completed some formal schooling but did not have a diploma, settled in Sierra Leone. His mother, who was illiterate and had not attended school,

moved to the South Bronx, NY, where she would sell traditional West African clothing. Mamady would not see either of his parents again until he was sixteen. He worked guarding animals on an uncle's farm in Guinea during what should have been his elementary school years, such that he did not attend school much until age twelve. At that point, he moved in with another aunt and uncle and cousins in Conakry, Guinea. Six of his cousins went to school and studied with him and became his first learning community. They would study intensely for exams together, always engaged in a friendly competition for highest marks. Electricity was not consistent, so they studied in the compound by candlelight and a blackboard. Textbooks were valuable and scarce. This was seemingly the only way to make sense of the way that Mamady devoured books that were offered to him later at BELL. It was a rarity to see a high school student's books see as much wear and tear from frequent use as the tattered chemistry review book that Mamady held so sacred.

Around age twenty – his mother does not know dates, and the place where he was born was burnt down in the war, such that any records were lost – Mamady came to the United States with his younger half-sister, where they were re-united with their mother and other siblings in the South Bronx. With an eleventh grade education in Guinea but no records to show for it, Mamady was concerned about repeating high school, a common concern through BELL, and his first year at the school came with signs of brilliance as well as rougher spots, when he was uncertain as to whether completing high school here was for him. His learning and performance accelerated his second year at BELL, and he would never show any signs of slowing down thereafter.

He spent his second summer in the US as a paid American Chemical Society Project SEED student in a chemical engineering lab and enjoyed learning new laboratory techniques,

especially in light of the lack of hands-on opportunities in Guinea and BELL's lack of consistent running water in its science "lab" classrooms. Chemical engineering was not for him, but over time, through discussions and readings, a light bulb went off in his mind that he could help solve problems back home in West Africa – what had become his chief concern in life – through the power of science. As time went on, he zeroed in on pharmacy as his area of interest, as he saw the opportunity, the power behind such a career to not only help him to raise his own family's opportunities and resources but, just as importantly if not moreso, he could focus on solving the appalling lack of access to effective medications that he had witnessed in Guinea. He recalls the time when he and other family members came down with malaria, feeling lucky afterward that he was cured since the people providing medical treatment in the clinics were not really trained medical professionals, and they often made errors in their administrations of treatments. Mamady has vivid recollections of men peddling cassava powder on the streets as an antidote to malaria, and these memories spur him on to a relentless quest for changing these conditions back home.

The passion only grew during Mamady's third and final year at BELL, when he also served as a teaching assistant/co-teacher, laboratory assistant, and peer tutor. So strong was Mamady's commitment to peer group learning that he formed his own after-school classes, which he would generally lead, but which another student would lead at times if another student exercised greater expertise in the topic at hand. An avid soccer player and fan who would recommend that science needs a rebranding at a societal level to increase STEM interest, Mamady was the ultimate "player-coach" in the classroom that year at BELL, and after he graduated, a year ahead of the school's first class, he was among a cadre of ten students who participated in a paid research program through Project SEED, this time in a pharmacology lab.

The young man who had been observed just a year earlier writing his goals on his shared bedroom wall, in pen, was now taking trips to the likes of the New York Academy of Sciences and would then go off to college intending to be a pre-pharmacy student. Mamady credits the paid research experiences, as well as his experiences with mentors and teachers, for helping to make science come alive for him as a viable and exciting career option (Rosa & Mensah, 2016).

Aissatou

Aissatou has a certain fierceness and intensity about her. It is a quality that at times led some classmates and teachers to view her as overly rigid and aggressive in her behavior at school. When considering her background, however, it seems more likely that the intensity is a crucial ingredient to a self-made, modern yet religious young woman from a highly traditional, patriarchal, somewhat tribal society who has already made it quite far, despite a lack of most any advantages that American educators could imagine. Aissatou's parents did not have a formal education, and despite this, she cites her mother, from whom she was separated at age 9 to attend a decent elementary school, as her chief inspiration for entering a science career focusing on human health. Her mother suffered from arthritis and possibly other conditions, and from the time she was a girl, Aissatou felt a certain passion pulling her to one day be able to help her mother to feel better.

Aissatou met her father, who had moved to America and found work as a tailor in a West African market in Harlem, at age 16, and would move with her older brothers (none of them high school graduates) to the Bronx to live with him a couple years later. Aissatou arrived at BELL High School at age 18 with an 8th grade public school education from Senegal, where parts of her family had moved from their hometown across the Guinean border. As she learned more

English, her unwavering determination was matched by a rapid acceleration in her learning and academic proficiency that was directly proportional to her devotion to her studies.

One day in 11th grade science class, one of the louder and more imposing young men in her class spoke up disrespectfully to a teacher. At the end of the period, Aissatou pulled him aside and sternly told him, "That was inappropriate, unacceptable, and you are not going to act that way with our teacher again. Do you understand?" The instructor called her over to exclaim his wonder at what he had just witnessed. Aissatou simply responded, "This is what I do."

This interaction reflected Aissatou's intensity as a student and a young woman that is seen constantly in her untiring devotion and serious approach to her studies, in and outside of class time, and in the loyalty to following those whom she views as important in her life. Aissatou spent long hours at school and at home studying chemistry, as well as her other subjects. Her demeanor and high expectations for herself were never lost on those privileged to know her. One time, at an advanced chemistry study dinner at my apartment late in her senior year, when many other students have developed senioritis, I was joking around with the other students at the dinner, while Aissatou's facial expression was serious, with her face down, intently peering into a book.

While at BELL, through her classes and her summer research placements in a physiology laboratory and a chemistry laboratory, she would come to embrace science as the key to reaching her goal of helping her mother, and the world more broadly, through medicine. She has remarked that she knew early on in life that medical careers were for her, but at that point, she had no idea what that meant. Only after really learning science – especially chemistry – here in the United States, in and outside of the classroom, beyond the rote memorization of science in West Africa, did she, like Mamady, connect science with her broader goals for helping those

around her. She found that she loved chemistry, and science more generally, and that she also truly enjoyed the complex process of learning science.

Aissatou would then plan to pursue a Bachelor's degree in Nursing, with this particular focus stemming largely from a desire as a young girl to help her mother when she got sick or was suffering from arthritis. Her mother back home and her father in the Bronx, as well as the older brothers who she referred to as her closest friends, believed in her, but Aissatou's drive came mostly from her own volition. Her father and older brothers held her responsible, as the woman of the home, for most of the cooking and cleaning for the family, and she was also working part-time in a clothing store to help the family. Like Mamady, Aissatou could have likely slipped through the cracks of school without her family members being able to help (her brothers worked, with two going in and out of GED programs to try to earn their own high school equivalencies), but this was a thought that she simply could not entertain, with a strong belief in herself and incredible internal locus of control that keeps her eyes fixed squarely on her goals.

Angela

Angela was different from other BELL students, and that became clear in her first few days at the school. She had just arrived months before in upper Manhattan from El Salvador, where she had attended a charter-like school with an increasingly highly-regarded reputation, and she had won scholarships to study English while in El Salvador. She had already spent her first summer in the United States immersed in an intensive English program for high school students at a local community college. Following divorce, family alcoholism, and a generally trying home life, in which Angela had become responsible for herself and anything she needed from the age of 10, Angela came to the US with her younger brothers and their mother, who would work as an assistant pre-school teacher.

They were brought to the US by Angela's aunt, a former refugee from the Salvadorean civil war of the 1980s who had raised herself up out of poverty as a girl in the Bronx to become a highly successful medical professional. Aunt Karina offered Angela all the connections and cultural knowledge – key social and cultural capital – that was so rare within Angela's new school and community, but would be so invaluable for navigating her future educational opportunities. Angela soon enrolled in after-school and weekend enrichment programs, including a Saturday STEM program, at the elite women's college that she would aspire to attend.

While Angela was an immediate star at BELL – she completed several college courses during the evenings through a local dual enrollment program prior to graduation – and was significantly aided by the advice and help of Aunt Karina, at home Angela would find herself "mothering" her own mom more frequently than the reverse. It was Angela who was in charge of overseeing family finances, of translating, and of helping the family to avoid eviction during her senior year at BELL. Angela has long been fiercely independent, recognizing her aunt and a teacher as mentors but insisting that her success relies on "me, myself, and I." Academically, she had loved chemistry since being introduced to it in El Salvador, fascinated by the ideas and concepts, and that continued at BELL. She conducted summer research through ACS Project SEED the summer before her senior year at BELL, focusing on investigating different crystalline polymorphs of cystine kidney stones as a method of breaking up the stones, which led to a fine research paper and a poster presentation at a national conference of the American Chemical Society. At the same time, she was also balancing college and high school classes with coordinating every senior class program and completing college and scholarship applications to

some of the nation's finest institutions so she could pursue her dreams of a career in science, perhaps in neuroscience and maybe as a pre-medical student.

Xiomara

Xiomara was one among the few dozens of students who started at BELL on the very first day of the school's operation in 2008. Speaking no English and carrying a mediocre record from a polytechnic high school in the Dominican Republic, Xiomara had just arrived in the West Bronx from a tiny village in the DR. She immediately impressed teachers with her focus and participation in class, even if it was nearly all in Spanish during the opening quarter. Xiomara lived with seven family members, and a number of pigeons, in a tiny one-bedroom basement, with the bathroom outside of the "apartment" unit. Nonetheless, this would be the environment that would promote success for Xiomara, in addition to the space in BELL classrooms that Xiomara and her friends would frequently use after school to hang out and complete work. Indeed, in her third year at BELL, a table in the middle of her science classroom would become like a home base for completing increasingly demanding and rigorous homework, especially in Chemistry and American History, and for organizing herself, meeting and working with friends and other classmates, and more.

The environment would seem non-ideal to most, but for Xiomara, it formed a welcome reprieve from the way she had spent her early and middle teenage years, in charge of her younger and older siblings and functioning as both "mom and dad" after her mother left for America and her father was too much of a chronic alcoholic to contribute to the household (when he was present). Although she experienced relative affluence in her childhood as her mother worked around the clock at four medical laboratory technologist jobs at the same time – affluence in her neighborhood context meaning she always had food to eat, relatively consistent electricity, and

some new clothing – all of that changed when her mother moved to the United States in search of a better life for the family. The problem was that her mother did not speak English, and it would take four years until she could send for Xiomara and her siblings, and three more years until she could land her dream job, as a blood bank technologist at a local public hospital.

Xiomara recalls the electricity being shut off because they could not pay for it, and she recalls having little or nothing to eat. She and her brothers and sisters would try to go to friends' houses in their village to eat dinner. All of the siblings, however, would remain in school. Neighbors in their relatively isolated village widely criticized Xiomara's parents for their actions, but one woman also remarked to Xiomara in awe that all of the children still attended school regularly, while she had trouble getting her own children to stay in school, despite her presence at home. Xiomara relates that while they had few material resources, both her mother and father had instilled the importance of education for independence in her from a young age, an important transference of cultural capital often observed by Gandara in her study of extremely high-achieving students from poor families (1995).

Xiomara's mother had made great sacrifices to pursue her career as a successful lab technologist, and her father, who made sure she understood the importance of an education as a girl so that a man could not take advantage of her, was referred to by his family as the "lost brain." While Xiomara's family valued education, however, Xiomara also felt like she was cast as the black sheep of the family, as the daughter who was "chosen" by some sort of default to run the household when her mother left. She felt that expectations were lower for her than her brothers and sisters, and one older sister told her that she expected Xiomara to get pregnant and have a baby by age sixteen.

Fast-forward to the spring of 2012, where following exceptional performance throughout her time at BELL, a newfound passion for nanotechnology was born within Xiomara. The seeds had been planted during two summers of mentoring and research on functional DNA nanoparticles in a prestigious chemistry laboratory, as part of Project SEED. She decided just after her twenty-first birthday, as she was about to speak at graduation as class co-salutatorian with Aissatou, that she "wanted to be part of the exciting new world of nanotechnology," around the time that she was preparing her part of a school science journal in her advanced chemistry class, suddenly blurting out how "a certain sensation comes over me when I read about nanotechnology."

BELL: SCHOOL CONTEXT

By the time of high school graduation, the four students introduced are representative of some of the most highly motivated and highly skilled students from BELL's inaugural class, and in its 7.5-year history to date. They brought with them unique sets of qualities and background experiences that were sometimes common to multitudes of other BELL students, or at least to its students aiming for careers in science, technology, engineering, mathematics, and medicine-related fields, but in some ways a given student could seem like an outlier even in this group. While maintaining the novel perspectives brought by various students, overall this investigation has aimed to find common ground and themes to link the approaches, experiences, characteristics, and factors that seem to tie many of the students together, especially those who have gone on to persist in their STEM career goals (and sometimes contrasting them with those who have departed from these goals).

The bar for "STEM persisters" was intentionally set at students who matriculated and persisted in a STEM-related major at a four-year university. While some may read the

descriptors of these students and argue for a focus on matriculation and success at just the community college level, this is explicitly not the goal for these BELL students for multiple reasons. The belief system and consequent approach at BELL has always been about maximizing students' future opportunities, and prior research has shown that a given student who starts at a four-year college has a 30% better chance of completing a Bachelor's degree within six years than if s/he starts at a community college (Bowen, Chingos, & McPherson, 2009). (Furthermore, a growing body of research warns about the long-term negative impact on college graduation of students from high-poverty schools who "undermatch," matriculating at institutions below the "level" of colleges in which their high school performance would suggest as a best fit for them. This case may be considered moot for BELL students due to their SAT scores, but with a growing test-optional movement – sadly not as often extended to the world of Opportunity Programs that can make four-year colleges truly affordable and accessible to low-income students in New York State – acting on research suggesting the importance of performance in high school performance over flawed SAT scores, the "undermatch" hypothesis does seem relevant with relatively high-performing students at schools like BELL who are far too often challenged into community colleges.)

In the context surrounding BELL, the wildly contrasting opportunity structures available to BELL students are especially apparent at local resource-strapped community colleges, where about 1 in 50 full-time freshman graduate in two years and about 1 in 9 graduate in three years, versus public and private four-year universities with Opportunity Programs. Furthermore, most BELL students are deemed inadmissible to the community colleges' more highly acclaimed student retention programs due to Regents and other test scores, and in some cases the apparent mismatch between relatively high grades and very low test scores. On the other hand, several

dozen four-year universities throughout the state offer state-funded Opportunity Programs aimed at supporting economically and educationally disadvantaged students with high school credentials slightly lower than a given institution's traditional admissions criteria. Such institutions and their Opportunity Programs, while rarely known to serve newcomer immigrant English language learner students, were seen in the eyes of BELL's founding principal, as well as by many colleagues as well as myself in my teaching and college access advising capacities, as beacons of potential that would be worth the time and energy needed to advocate and build relationships in the very same vein as the emancipatory frame of this research study. Put simply, there was a deep belief by BELL, even with limitations in the availability of courses and structures that other researchers would deem necessary to build strong pipelines to success in four-year STEM majors (Weis, Eisenhart, Cipollone, Stich, Nikischer, Hanson, Leibrandt, Allen, & Dominguez, 2015), that if only the students could be given opportunities and support, they could – and would – succeed.

At first glance, BELL may seem an unlikely proving ground for the development and testing of such a system. For each of its first four cohorts, graduation has been a struggle, with 35-45% of each entering class going on to earn a high school diploma. The school continues to work on retaining and graduating students, with definite help from recently amended state graduation requirements for schools in BELL's network, but dismissing BELL as a low-performing dropout factory would be missing the boat. BELL was founded in response to a dire unmet need to educate and provide brighter futures to older high school students who had just immigrated to the US and did not understand English, admitting them regardless of prior education and literacy in their native languages. Without BELL existing, the vast majority of its students would not have a high school to attend, let alone one that strives to provide individual

attention to meet their unique social, emotional, and academic needs. Before the school's founding, the main options for 17 and 18-year-old newly arrived immigrants without a high school diploma were Spanish or English GED programs or just going straight to work, with some students on the younger side given the option to be rushed through a high school program to meet minimum graduation requirements. Such options were not particularly conducive to college success in general, let alone in highly sequential STEM fields. Hence, without BELL, the school's students, including those who barely "drop in" before deciding that full-time high school is not for them as well as those in this study, generally would not have had a chance to earn a high school diploma in their new country.

While progressive and college preparatory in its ideals, BELL has not offered a plethora of science and mathematics courses at levels that college admissions officers and faculty would consider to be "college ready" in practice, and faculty recruitment and retention is a large challenge as it is in so many high-needs urban schools (and far more so than is the case in the Humanities), and also a major variable in the ever-shifting scope and sequence, as well as the specific courses offered by the science department. In keeping with the principles of its network, a group of public high schools serving recently arrived immigrant English language learners, students are grouped heterogeneously in their classes, and there are no Honors or Advanced tracks, largely in response to the historically inequitable intra-school distribution of learning opportunities in racially and class-integrated high schools (but with potentially different ramifications in environments with such blaringly skewed inter-school opportunity structure differences, as is overtly the case in the hyper-segregated schools in New York City).

With harrowingly steady streams of students enrolling and then falling off in waves a few months, or a year or two, after giving full-day schooling in the United States a shot, the school

continued trying to build strong, supportive relationships with students while brainstorming new strategies to support and retain students. Despite these efforts and the school's extensive personal touch, many would continue to leave to work full-time, to take care of their own children, to try to complete a GED faster via a BELL diploma (a goal that was rarely met among the dozens who tried), to return to their home country, to handle challenging home situations, or as a result of losing hope from continuously failing required state Regents exams. The academic components to students' frustrations were often the result of some combination of many students' very low skills based on limited formal education prior to BELL, limited time to commit to studying due to some array of factors from the preceding list, and in some cases learning differences that would have resulted in an IEP and consequent services if the student had been in the US from a younger age. The issue of giving up in the face of failing multiple Regents exams has decreased in magnitude over the past year, with morale and hope going up especially among students struggling with attendance, literacy and numeracy, and basic skill development. While continued efforts by BELL counselors and teachers play a role in this, the change is likely due in large part to the school's amended state graduation requirements comprising five performance-based assessment portfolio tasks and two Regents exams, rather than the five exams previously required.

Performance-based assessment in the form of portfolios have always been viewed as central at BELL as the preferred means of formative and summative assessment, in line with the school's decidedly social constructivist views on student learning. The expectation and standard set by BELL's administration has always involved teachers working together and with instructional coaches to craft project and inquiry-based curricula, in science as well as other subjects. At times, materials were adapted from curricula developed by other newcomer ELL

schools in BELL's network. With the exception of chemistry classes, BELL classes rarely made frequent use of outside textbooks or curricula, even those that reflect a similar project-based, constructivist approach. In BELL's early years, every instructional unit in science and other classes was to be inspired and punctuated by a high-interest project, but as the school has expanded and staff and students' needs have evolved, the consistency of inquiry and project-based learning, and what it looks like, has also evolved. Collaboration and group work are valued at the teacher level just as it is expected of students in classrooms as part of the beliefs that knowledge is socially constructed and that, as English language learners, students need as many opportunities as possible to develop and practice their reading, writing, speaking, and listening skills in their new language. Indeed, for the first six years of BELL's existence, when five Regents exams were required for graduation, the school maintained an annual set of required portfolio presentations every year in each core subject.

In terms of the courses students experience while at ELLIS, in science and math as well as other areas, they spend two years in mixed-grade "Junior Institute" classes (or one if they show themselves to be relatively advanced by the end of their first year). The focus in these classes is first and foremost on the development of work habits (including "learning how to be a student" for many who were accustomed to four hours or less of school per day, or who were out of school for much of their adolescence) and basic interpersonal communication skills in English. Group work is also integral to these classes, and more advanced second-year students are frequently grouped and expected to help first-year and struggling second-year students with native-language translation and meaning-making.

Building content knowledge takes on some importance, especially in the second year, but the pace and level of work is generally dictated largely by the language skills of the students

linguistically and academically in the "mid-range" within a given class. Junior Institute math classes typically focus on students building a basic conceptual understanding of pre-algebra and algebra I topics, with some time also dedicated to the basic arithmetic and numerical fluency skills that most incoming students have not yet mastered. Junior Institute science classes focus on building students' scientific inquiry and experimentation skills and, in the early years of BELL, a content focus on the physical sciences, and chemistry in particular. Due to Regents exam pressures and the educational backgrounds of science teacher hires over the years, Junior Institute science shifted toward the biological sciences.

The final two years at BELL are referred to as "Senior Institute," featuring classes that are decidedly more content-heavy and, in some classes (depending on the teacher more than the subject matter) a significant uptick in expectations, difficulty of work, and homework load. It is a time of shifting from developing students' basic interpersonal communication skills in their new language to the next uphill battle of building their cognitive academic language proficiency. The term "battle" is used because language acquisition research has shown time and again that five to seven years are required for an individual to achieve full academic language proficiency in a new language (Collier, 1989), while BELL students only have three or four years (more time than most wish to spend) to graduate and then go off to college. (BELL allows and encourages students to stay past age 21 when needed – the school just does not get funding for these students – and past four years of study when needed, but as one may imagine, more barriers to full-time study can arise as time continues to pass and students continue to grow older.)

"High expectations, high support" has been a dominant mantra at times by certain Senior Institute teachers and administrators focused on fostering college readiness and college-going culture and habits of mind and work. As has sometimes been the case in Junior Institute, the

level at which Senior Institute physical sciences courses could be taught has generally been mediated in part by the quantitative skills of the student body at a given point in time, so explicit attention has been given over the years to helping students with their algebraic and basic data analysis skills in science as well as math classes. Students have generally completed some combination of a biology/chemistry hybrid, chemistry (Regents-level in the early years, more general since then), and/or conceptual physics courses during their two years in Senior Institute, with a large culminating portfolio project and presentation at some point during each school year. In the case of the first cohort, when I taught all the students in their first year in the Senior Institute (11th grade), there will be some further discussion of these projects later in the chapter, in cases where the experience was seen as directly relevant to future STEM majors.

In recent years, students have been able to elect into a supplemental, hands-on Principles of Biomedical Sciences laboratory course, held largely after school, as well as a college-level Biology course, through grants that the principal and I were able to secure to bring Project Lead the Way and dual-enrollment college-credit courses to the school to build a fledgling biomedical pipeline program. Smaller numbers of students also completed other advanced and college-credit courses in mathematics and science, off-site at local city colleges or through small-group and independent study with a faculty member at school. These course opportunities outside of the standard BELL curriculum, along with extension and other activities that sometimes complemented them, will be considered further in the next chapter, which focuses on students' transitions to college.

ASPIRING TO STEM FROM BELL: INTRODUCING THE STUDENT PIPELINE

Through its first four graduating cohorts, BELL has graduated a total of 135 students, including 100 "on-time," by June of their fourth year enrolled at the school. (The meaning of

"on-time" is restricted here to time following enrollment at BELL, as these students are regularly 20 or 21 years old upon graduation, and most have been enrolled in some form of high school for a total of five to seven years.) In line with BELL's focus to help send students to college, over 90% of graduates matriculate to college within a year of their high school graduation, including over 95% among on-time graduates. A total of fifty-nine of these students are currently studying at four-year colleges; sixty-two students initially matriculated to four-year colleges, with seven leaving (to two-year or certificate programs, taking a break, or dropping out) and four transferring in from two-year colleges.

The vast majority have matriculated at upstate public and private colleges due in large part to significant uptick in emphasis that New York City's public four-year colleges' have placed on SAT scores, at odds with the average math and reading scores each huddled around the 320-360 range among BELL students with a 79-100 (or 2.4-4.0) GPA. These scores represent the BELL students who were in good standing by the fall of senior year (when college applications occur) for on-time graduation and could be candidates for at least some four-year Opportunity Programs. Unfortunately, even the less selective of these institutions' Opportunity Programs for low-income, like those of low to mid-level New York City private and public universities, tend to require SAT math plus verbal scores well into the 800s to the exclusion of other redeeming qualities (e.g. compelling personal essays or recommendation letters). BELL's unique hybrid relationship- and data-driven approach to college access counseling, which will be described in the next chapter, helped most of these students to be able to be admitted and financially capable of attending four-year colleges.

Of the sixty-two students who matriculated to four-year colleges, forty-one of them intended to pursue a degree in a STEM-related field, which includes health professions/health

sciences programs, for the purposes of this study. Another two students intended to pursue a degree in the STEM-related field of architecture but instead enrolled in interior design majors because of generous scholarship/financial aid packages that were not close to being matched by the one university that accepted them for architecture. An additional five students, all females, were strong candidates to matriculate to four-year STEM degree programs but were in family situations such that they had to study in local community colleges; these students were generally married and with a child at or shortly after the time of high school graduation, and one has transferred to a four-year college where she is completing a Bachelor's degree in engineering. Four students, all Dominican males, who had been very enthusiastic science students and likely future members of the pipeline through part of their junior or senior year at BELL, are not among the forty-one; three had grades that precipitously dropped off toward the end of their BELL careers amidst personal and family turmoil and/or mental illness, as well as an ongoing physical illness in one case, while the fourth returned after graduation to study in his native country, where his mother was a physician and his experience would be quite distinct from that of the focus of this research.

Defining the STEM Persisters and Switchers: Demographic and Childhood Background Overview

Of the forty-one students who went to four-year college with STEM degree aspirations, thirty-seven remain enrolled in four-year colleges today, including twenty-seven in STEM majors. Some background contextual data is available for all forty-one students, to offer a comprehensive overview of all BELL STEM persisters and switchers, but the focus of the in-depth investigation focuses on the twenty-seven STEM persisters and ten STEM switchers who are still enrolled in four-year colleges today. These chapters will integrate some descriptive

quantitative data with ethnographic observations and narratives, while Chapter 7 offers a more complete quantitative breakdown of the switcher and persister sub-groups. (In some cases, complete information is only available for persisters.)

Of the twenty-seven STEM persisters, a majority (fifteen) are females, which contrasts somewhat with the 60% of BELL's student body that is male and the gender-balance observed in STEM fields at large (which is somewhat different including health sciences/health professions, as is the case here, rather than when excluding them, a common practice in some prior studies). Just five of fourteen STEM switchers are females, and as will be seen later, they were stronger academic performers in high school than eight of the nine males who would later switch out of STEM.

Thirteen of the twenty-seven persisters are Latino/a, including ten from the Dominican Republic, one from Nicaragua, one from Ecuador, and one self-identified Afro-Latina from Colombia. Another ten of the persisters are West African, including four from Togo, three from Guinea, and one each from Senegal, Cote D'Ivoire, and Sierra Leone. The remaining four students were from South or Southeast Asia, with two from Bangladesh and one each from Vietnam and Nepal-Bhutan (one of the 100,000 Nepali-ethnic Bhutanese refugees resettled in the US over the past eight years following nearly two decades in refugee camps in Nepal). Of the switchers, eleven were Latino/a (eight from the Dominican Republic, one from El Salvador, one from Honduras, and one Garifuna Afro-Latina from Honduras), two were from West Africa (Guinea), and one was from Southeast Asia (the Philippines). Given that BELL's ethnic breakdown over the years has generally been 75-80% Latino/a (with the vast majority being Dominican), 15-20% West African, and 4-5% South/Southeast Asian, students from the Dominican Republic seem to be very underrepresented among persisters, with West African and

South/Southeast Asian students relatively overrepresented, with distinct ethnic/racial breakdowns for the persisters and switchers.

Reflecting back on their childhoods, over two-thirds of eventual STEM persisters recall taking an early liking to math and/or science by the age of 10, interests that were mostly reflected in liking what they knew of math or science in school, but with a few students expressing hobbies related to tinkering or exploring the nature around them. Just under half of the students, both persisters and switchers, consider themselves to have been naturally drawn to science and/or math, with the balance indicating that they had to be led to an interest in these areas by someone or something external to themselves. None of the students were involved in extracurricular activities related to science, math, engineering, or medicine in their early teenage years prior to coming to the United States, except for a few who were part of local math competitions. While many students would refer to experiences following their immigration as integral to their current career goals, STEM persisters recall deciding on wanting to pursue some career under the STEM umbrella at an average age of 14.5, two years younger than the average for the switchers.

As is typical of BELL students at large, the average age of immigration to the United States was between seventeen and eighteen for both persisters and switchers, with an average age at high school graduation hovering around twenty-one. (The persisters from the U-State comparison group mostly arrived at a younger age, including two from immigrant families where a language other than English is spoken, but who were born in the US. Only two of the nine U-State comparison group members were "over-age" students who arrived at age sixteen or later and graduated from high school at age nineteen or older.)

As is very common among children and adolescents in immigrant families in the US today, most of the students in the study were separated from one or both parents for several

years, sometimes their entire childhood and adolescence. For many BELL students, including those in the study, family reunification policies allow them to come to what many in their homelands have referred to as a golden land of opportunity, but it is often with a great deal of psychological stress and trauma, being uprooted from one's community and home support structures to live with a parent who one barely knows and who often has great difficulty finding ways to rekindle a relationship with an older adolescent that has laid mostly dormant for ten to fifteen years (Suarez-Orozco & Suarez-Orozco, 2001). Some students have had more of a constant parental presence and less of this stress than others. Eight of the persisters' parents, and one of the switchers' parents, are still married. Six of the persisters were raised for most or all of their childhood with both their mother and father, three of whom immigrated together with their parents to the United States; none of the switchers were raised in their country with both parents. Ten of the persisters, and two of the switchers, have at least one parent who raised them for most or all of their childhood and adolescence in their home country and lived with them following their immigration to the United States.

Family Education, Neighborhood, and Socioeconomic Status

The STEM persisters are definitely educational strivers in their quests for college degrees, and often graduate degrees, with the mean number of years of schooling completed by their mothers and fathers around 10 and 11, respectively. Eleven of twenty-seven mothers and seventeen of twenty-seven fathers had completed at least a high school diploma. Seven of the persisters had two parents who had completed at least high school, four of whom had one parent who had graduated from college. Another twelve of the persisters had one parent who had completed at least a high school diploma, four of whom had also graduated from college. The remaining seven persisters did not have a parent who had graduated from high school; in four

cases, both parents attended school for between zero and eight years. In total, of the eight parents (out of fifty-four) who were college graduates, one had a science degree (but was never permitted to use it due to political situations in the home country and a lack of English proficiency in the US). Four of the eight are custodial parents of the students here in the United States (including one who earned her degree here in the US, as a working adult), two of whom work in positions related to their degree. While parents present in the US had a variety of different jobs, as seems to be the case at BELL more broadly, the most common jobs of STEM persisters' mothers and fathers in the US were home attendant and taxi/livery driver, respectively.

In terms of socioeconomic status in the United States, twenty-four of the twenty-seven persisters and twelve of fourteen switchers were economically eligible for university Opportunity Programs, generally with annual family incomes in the $15,000-35,000 range. (Of the three persisters who were not OP-eligible, two had one parent who had graduated from college.) All of the students were eligible for Pell grants, federal grants that are reserved for students from lower-income families. With few exceptions, the students' family incomes, like their native languages and ethnicities, were reflected in the neighborhoods where their families reside, which in many ways became their new environmental reference frames through which they would experience and understand life in their new country. The Dominican and other Latino/a students tended to live in largely Spanish-speaking neighborhoods throughout the South Bronx and West Bronx as well as upper Manhattan, and the West African students often lived in heavily West African enclaves within the South Bronx and West Bronx. The two Bangladeshi students also resided in the Bronx, but significantly west or southwest of the borough's two main pockets of their countrywomen and men. The Vietnamese student (the only student from her country in

BELL history) lived in a pocket of the West Bronx that has seen an influx of immigrants from her homeland in recent years. The Nepali-Bhutanese student did not live in an area near others who shared his language or ethnic background (and the refugee group influx of which his family was a part would, for the most part, clear out of New York City to resettle in smaller, lower-cost-of-living cities throughout the US).

In 2013, the Washington Post used US Censes and American Community Survey data to create a map of all of the nation's zip codes and classify them by socioeconomic status percentiles based on residents' median household income and educational backgrounds (Chow, Andrews, Mellnik, & Morello, 2013). While created to highlight "super-zips," or concentrations of the nation's economically and educationally elite communities, many of which are huddled tightly along a strip of the eastern seaboard from northern Virginia northward through Boston, one can conversely come up with very sobering visualizations of regions of concentrated poverty in examining the colors and numerical data in certain rural and urban-center locales. Zip codes in the bottom quartile are barely visible in a dark blue hue that is not much different from the black color used for unoccupied regions such as bodies of water: the poorest regions seem to nearly disappear. The five boroughs of New York City have a total of eighteen such zip codes, and thirteen of the eighteen (including twelve of the city's only thirteen zip codes at the 10^{th} percentile or lower) form a contiguous region of the South Bronx and West Bronx.

As many of the BELL students would share with me and with their friends over the years, from information conversations to Facebook statuses and memes, the United States was far from the land that they had imagined, the land where money floated through the streets that they had heard about in the movies or from their own family or community networks. Seventeen of the twenty-seven persisters (and seven of fourteen switchers) lived in these especially economically

depressed areas, with median household incomes from $19,840-31,707 and where 9-17% of adults had a college degree. The remaining students tended to live in zip codes with decades-long ties to the Latino and/or Black communities, parts of which have experienced significant gentrification in recent years, or which have long been characterized by a distinct split in social class and race along a particular border such as a major street or a hill.

Overview of Academic Performance at BELL

Many persisters and switchers worked part-time jobs while at BELL, but they also found significant time to dedicate to their studies, especially in science and especially in their time in the Senior Institute. Persisters and switchers reported spending an average of 4.6 and 4.3 hours per week, respectively, studying and completing homework related to their science classes. In math, they reported averages of 3.8 and 3.1 hours, respectively. The culture and sentiment among students, like most staff professional development, seemed to sharply emphasize English language acquisition, with many BELL students openly relating their feelings that they were in school to learn English and thus preferring explicitly English-related work. While science and math courses involved English language development, this was generally not at the front of many students' minds (as evident from comments over the years of feeling that what they needed was English skills far more than science, math, or other skills, which many felt they had had enough of back in their countries), but among STEM aspirants – both persisters and switchers – reported doing more science and math coursework than the more explicitly English reading and writing-oriented social studies and English classes (i.e. Humanities classes). Curiously, however, averages of 4.3 and 3.5 total hours of weekly Humanities homework and studying were reported among persisters and switchers, respectively, indicating significantly less than their cumulative math and science study time despite the even split in core class time. Persisters and

switchers' overall distribution of study time were similar, but perhaps not surprisingly, persisters displayed somewhat larger averages of high school study time in all three areas.

In line with BELL's collaborative spirit, as well as the later onslaught of the "Homework Club" and later incarnations of structured extended-day studying and tutoring opportunities, students reported spending just over four hours per week working on math and science homework after school *at school*, often working together with their peers: 4.4 and 4.1 hours, respectively, for eventual persisters and switchers. Frequent involvement teaching one's peers was a popular behavior among persisters in particular. Sixty-three percent of students who would persist in STEM reported tutoring (or "co-teaching") peers in science or math in or outside of class at least once per week, compared to thirty percent of switchers.

Within the context of the BELL community, the students in this study were relatively strong. On average, the persisters were A-/B+ students (average GPA 89.8%) and the switchers were B students (average GPA 85.5%), albeit with significant variation within each group. Science and math GPA were a bit lower for both groups, but with eventual persisters once again producing higher grades than switchers, at 88.4% versus 84.4%. Grades are one important variable, but colleges, like the state and much of the outside world, would judge the students and school largely by their test scores in attempts to compare them to students from other schools and against externally defined benchmarks for the likes of college readiness. On the required state Regents Algebra I exam, which many students took multiple times, persisters and switchers would average a 78.8 and 75.9, respectively. Also notable, while at BELL, one-third of the persisters also took a more advanced math course (Intermediate Algebra, Pre-calculus, and in two cases Calculus I) than was available at ELLIS through a local college, as did one of the

fourteen switchers. Some also participated in other advanced course opportunities that BELL would develop over the years, but these will be discussed in the next chapter.

(Science scores are difficult to average and compare in a meaningful fashion. Most of BELL's first cohort in the study passed the Chemistry Regents as their required Science Regents exam, while the rest of the first cohort and all of the second, third, and fourth-cohort students would count the Living Environment exam as their Science Regents exam and most would not sit for the Chemistry Regents. The two exams are difficult to compare, evaluating vastly different content and process skill sets, with passing marks on only the Chemistry exam being considered a college-readiness marker by the New York City Department of Education, and with different grading policies reflecting the far broader participation in the Living Environment exam than the Chemistry exam across the state.)

The SAT and the Disturbing Status Quo of College Admissions

On the SAT, where students would not be permitted extended time as English language learners (unlike state exams), their scores were decidedly less competitive, but with a larger difference between eventual persisters and switchers, especially in math. SAT math scores averaged 423 and 374 for persisters and switchers, respectively. SAT critical reading averages were 355 and 364, resulting in composite SAT score averages of 778 and 738, respectively. (Exact scores were not available for all nine students in the U-State comparison group, but math scores were generally in the low-400s or higher, and reading scores were generally 400 or higher as well.) New York City's lowest-scoring schools on the SAT tend to be in the Bronx and schools that serve predominantly English language learners. Indeed, for the year 2014, among the eight lowest performers among the city's 440 public high schools, seven are in the Bronx and seven serve exclusively English language learners (six meet both qualifiers). These eight

schools, BELL among them, are places where the average SAT-taking student has a math plus reading total in the low to mid-600s. The averages reported above for the BELL alumni in the study corroborate that these students look relatively stronger than their within-school peers, but they still fall far short of what college admissions officers, as well as prior researchers of STEM majors, expect of individuals with a potential to succeed in STEM fields. The scores can be downright shattering to the hopes of many students when they find that the city university system's four-year colleges, for example, will generally not look at them.

Critical researchers, like progressive educators, may discount the SAT for a variety of reasons, citing widespread evidence that strong performance in challenging high school courses are more important. Regardless, these scores continue to maintain a key bridge-keeping role in deciding future opportunities for students, regardless of how high their grades may be, especially when they come from high-poverty public high schools whose coursework admissions officers assume to be relatively non-rigorous. The esteem of the student's record falls further in the eyes of the bridge-keeping admissions officers when the school does not offer Honors or Advanced Placement courses or tracks. Try to apply to a particular university, or a college within a university, that is dedicated specifically to STEM disciplines, and one may expect disbelief with undertones of condescension, scorn, and laughter. Students with these scores, and thus these admissions profiles, are simply not considered to be legitimate STEM contenders.

This research offers the first evidence *ever* that students who "look" like this on paper in high school can succeed in STEM-related majors, and it goes far beyond just one student here or one student there. Exactly one of the twenty-seven STEM persisters crossed the 1000 mark, and one more scored in the 900s. Every other STEM persister had a composite SAT score between 560-890. In the math section – especially near and dear to admissions and scholarship offices,

and even this researcher until he had spent several years immersed in the BELL environment – exactly one student broke the 600-mark and one more crossed 550. Three other students scored a 500-510, another thirteen students scored in the 400-480 range, seven scored from 320-370, and two actually scored just 240, which is close to the score of signing and leaving the exam blank.

Roots to STEM: Pre-College Origins and Evolution of Interests

The persistence and success of these students begs a number of questions. What is going on here? How do they do it? How are these "persisters" actually doing in college? How do they talk about their trajectories, and what do they recommend to peers, educators, or others who want to replicate their successes and learn from their struggles? What lessons lie in store for educators and researchers who wish to help more students to join and remain on the path toward entering a rewarding STEM career? How can the status quo be shifted such that some challenges can be flipped to be considered as strengths or marks of potential? Before following the group in their transition to college and journey through college, it is helpful to "meet" several of them and better understand the early origins and evolution of what have become their current STEM career goals, beyond those of the four students who opened the chapter.

Sela, Cameron, and Giving Back: Extending from Mamady and Aissatou's "Necessary" Adversities and STEM for Social Responsibility

Sela had come a long way in three years at BELL since joining a father she barely knew, immersed in a language and culture that were totally new to her, and anyone who taught her could see that she was downright driven. The road from southern Togo, from the town she was born in after her mom had fled her home while pregnant with her after the military started walking through the streets and shooting indiscriminately, to the Tremont section of the Bronx,

and on to college would be a long one. Once, when asked to write a paragraph about the greatest gift she had ever been given, she wrote about her mother granting her the opportunity to go to school.

> *The best gifts are not only about what you are given. They are about what a person does for you because she or he knows that it will benefit you in the future. My mother's finest gift to me was her sending me to school. I am very grateful for that because it made me the person I am today. My mom was a poor single mother, and school in Togo was very expensive. She could have sent me to sell things on the streets because that is what people often do in our situation. Instead, she worked extra hard to send me to school. School taught me how to work hard to be successful.*

Sela was not referring to high school or college or the opportunity to one day attend medical school; rather, she was referring to her mother's decision fifteen years before to ensure that her daughter would go to school, unlike many girls from circumstances like hers, who would start working from a young age and would know the streets far better than any books. She had truly cherished attending school since she was a young girl, and she enjoyed science and found a particular knack for mathematics. Sela would talk with pride about her math skills as a Togolese student, as she would remark that the Togolese in her experience often take pride in their math skills, in how hard they are made to work in math classes in school; her father once excitedly told me of his own prolific math skills back when he was in high school, even being asked to teach the class to his peers when their teacher came down with what seems to have been a serious mental illness. Sela was not particularly close with her father, but she too seemed to pull some strength and solidarity from her father's high school math stories, and she was not the only

student who would find strength in family or community role models' experiences back in the home country.

Discussing her interest to study science and pursue a career as a medical doctor, it "is because medicine in my country is corrupt. If you don't know people, you will sit there for hours when you get sick and go to the hospital." She reflects back to one day when she was fifteen, "my step-father got shot many times in his leg, and we didn't know what to do. I felt useless. I don't like feeling that way." Sela's undertone of social responsibility as a driving force was a recurring theme in the narratives of BELL STEM persisters, in particular in medicine and other health professions. Her more specific focus on wanting to improve conditions and effect change in her country was quite common among West African students, in particular, and finding inspiration in a medical hardship faced by a family member was also frequently mentioned as an instrumental aspect of the root of career goals of persisters with medicine-related career goals.

Cameron also found strength and inspiration from her early life in her home country. She grew up in Colombia with aunts, and sometimes her mother, traveling from home to home without a lot of stability. Cameron, like Xiomara, had to grow up rather quickly, but for very different reasons. She found herself acting as her own mother's "mother" figure much of the time in her teenage years because her mother, who has special cognitive and emotional needs, has great difficulty with differentiating between healthy and unhealthy friendships and relationships, among other things. Cameron's mother, a black woman of Latina heritage who grew up in New York City in the 1970s, had had a very traumatic childhood, namely from witnessing her own mother's murder before she turned five, after which she entered the foster care system and was diagnosed with disabilities in school. There would be struggles with mental

illness, homelessness, and sexual abuse as life took her to Colombia, her family's country of heritage, after high school did not work out, and then back to New York. The first child, Cameron would live through many of the trials and tribulations with her mother, including some personal experiences with abuse that she rarely discusses. Her mother had caseworkers that followed and helped her in Harlem, and then when they moved to the South Bronx, with leading a healthy, independent life, working at different times in security, handing out daily newspapers at the subway, and as a custodian. She was a caring mother who had also internalized invaluable life skills, such as maintaining the utmost level of politeness, respect, and punctuality (she was generally the first parent to arrive for every parent conference or meeting at the school), and Cameron drew a lot of life lessons from her mother and her experiences.

Cameron's career interests have included dentistry as well as community and public health. She describes her interest in dentistry as stemming from her father having a variety of oral health issues, as well as from an aunt who had been in college to pursue a career as a dentist, but had to leave because of the cost of school. Her interest in community health issues are even more personal, coming from her lived experience of pain in watching close family members such as her mother struggle with some of the serious issues mentioned above. While Mamady and Xiomara had been more emphatic about it, Cameron's path, too, poignantly emphasizes the theme of channeling adversity in a very positive way to drive later growth and success.

Deepak: Self-Efficacy in Math and Science

Deepak came at his STEM interests, in medicine and later in computer science, from very different beginnings, but also demonstrated another theme observed in the way students describe how their career goals evolved. Deepak was born in a refugee camp in eastern Nepal shortly after his family had fled violent ethnic cleansing efforts in their native Bhutan. His parents, like

tens of thousands of other Nepali-ethnic Bhutanese who had spent many generations living in Bhutan, escaped to the camps after years of his father being tortured and jailed. He grew up attending schools in the refugee camp, including one that was started by his father, a teacher who had managed to get a degree in education in between the years of abuse at the hands of the Bhutanese government. During a home visit, his father would recount some of his remarkable experiences, from brutal physical torture (which eventually made him stop working at his security job in New York, two hours from the family's Bronx home) to being served pieces of food mixed together with petroleum and nails, all approached with a remarkable sense of grit and hope (even smiling to answer my question of how he ate in prison, "Well, first, you remove the nails…") that helped him to become a community leader in the camps.

Even as he would be pulled in different directions at times by his brother's mugging and his personal struggle with fitting in with other young men in the Bronx while also being a faithful son, at his core Deepak enjoyed talking about and doing math and science problems as well as talking with his science and math teachers about life and school back in the camp. On the one hand, he was able to attend a full-day school, which was very much not a given among other BELL students in their home countries (about half the STEM persisters attended school for less than six hours per day, in some cases just 3.5-4 hours); on the other, like a number of students from elsewhere in the world, his school year was regularly interrupted with unexpected closings, which he would describe in greater detail than other students. In addition to the refugee camp not having access to Nepal's electrical or water grids, the school building did not have a closed roof, so school was cancelled five to seven years per year for rain, cold, or monsoons. Sometimes there were also "political" closings, cancelling fifteen days of school in a bad year, where there were uprisings and fighting, and Deepak would hear gunshots and see people dying,

traumas far beyond schools simply closing. Deepak was generally positive about his school experience, though, even bringing one of his old textbooks to school to show his science teacher; it looked like a cheaper "international edition" paperback version of a standard, if thin, textbook at first glance, but there were also entire chunks of pages missing (e.g. the book would skip from page 104 to 208, and based on the binding it did not seem the pages had fallen out).

Deepak had long enjoyed mathematics and had strong self-efficacy in this subject. He once described his school receiving calculators, just as they received essential staples, from international relief organizations like UNHCR and UNICEF, and when I asked about the seeming dichotomy between having scientific calculators for complex math and physics problems but no electricity, Deepak's response was, "It's simple, the calculators run on batteries. We just couldn't use the electrical grid, that's all." While the context of the Nepali refugee camp was distinct from other students' experiences, Deepak's drive to enter a science career based on a strong sense of self-efficacy with respect to a set of skills (in his case, logical and mathematical thinking skills, believing that he could always reason his way through a problem) exemplified another major component of the origins of a number of BELL students' long-term goals.

JAM: Finding "Fun" STEM Learning to Finding STEM Learning "Fun"

"JAM" arrived at BELL as a nineteen-year-old with a puzzling academic history complemented by a long resume of work experience, so perhaps it was not surprising that his interest in STEM would be tied largely to experience outside of the classroom. JAM and his younger siblings were raised by his mother, who worked long hours in a factory after their father died on JAM's third birthday. Around the time that his mother had a major accident, JAM decided to quit school at age eleven to have more time to play soccer outside with friends, and would soon start working. (While maintaining a distinctive respect for traditional Nicaraguan

culture, JAM has long been very independent, and in typical JAM fashion, he actually completed his final interview for this research while driving me around the Bronx and Yonkers while coming home for the weekend from college.) For a number of years, he worked with an uncle driving livestock across Central America, and also worked jobs at a local coffee factory. He would try returning to school and enroll in computer classes as well, but would usually lose interest and not finish the year, but would sometimes stick around long enough to participate in local math competitions. Skipping a few of the grades that he decided not to attend, JAM completed a couple years of high school at a weekend school for working adults. When he arrived in the Bronx, the principal at his younger sister's school suggested he just try for a GED and hope for the best, which JAM took as an affront to his intelligence and potential.

JAM found and enrolled at BELL, where he would spend most of his time with the "six-pack," a group of seven Latino/a students that would become his support group and study group. When JAM feels comfortable in a setting, he is very open about his opinions, which was welcome but sometimes frustrating when he would, for example, leave a computer science internship shortly after starting due to boredom and not believing it would help him, or when he would critique a particular class on the basis of its pacing, homework, or other factors. The frustrating part was not really his discussing his opinions – the other teachers and I enjoyed hearing student feedback – but JAM's inconsistent effort, misaligned with what he seemed capable of when he really tried, and ability to community this in a productive fashion did get in the way of, perhaps, optimally advocating for himself and his peers at times.

I saw his potential shine through during the fledgling science/math club of BELL's first year, as well as his caring and insightful nature throughout various interactions with the "six-pack" after classes and outside of school, and on occasions where I, as JAM's advisor and

instructor, found learning experiences that JAM judged to be important or interesting. JAM lived near an access point to the Bronx River, actually along the side of a soccer field where he often played, so he took me there, as his teacher at the time, to collect water samples that would be used in a Bronx River water analysis investigation in class.

When it was time to work on the research paper regarding a water contaminant and region of interest, JAM dove into his project, in which he chose to focus on agricultural runoff chemicals that were contaminating the lake near the neighborhood of his youth in Nicaragua. Newly re-engaged, he looked nothing like the student who had earned a "D" in the class the first six months of the year, wrote a very insightful paper, and had a budding interest in environmental science careers alongside his longstanding interest in computers and information technology, which he would later refer to as his "comfort zone." He and his friends and I would even turn part of his family's Memorial Day barbecue in a local Bronx park into a chemistry studying picnic. Relationships and experiences where he built proficiency and comfort in an area of interest were important for JAM. He would later call himself "not a book person," as he sees himself learning more from doing. JAM engaged in STEM from being immersed in an engaging environment through work or activities that he considers to be leisurely (and/or activities that seem more leisurely through relationships he builds with individuals who are associated with them), and he would not be the only BELL student for which many of these descriptors would apply.

Ramon: Forging Learning Communities and Social Responsibility via Co-Teaching

Over the years, Ramon would be far more than a student within the BELL community and a neighbor of mine. I had the privilege of gaining a significant lens into Ramon and his classmates' lives through conversations well after the school day and during evening commutes

home together on the train and what would become a mechanical three-block walk home from the train together. From Day 1, it was apparent that Ramon learned quickly and enjoyed school. In an urban public school context where tardiness, absences, and becoming an LTA, or "long-term absence," were all too common, especially for older teens like Ramon who had viewed BELL as a place where they were forced to repeat high school (he had completed 10th grade in the Dominican Republic, which was very common among entering students), Ramon was neither late nor absent a single day throughout his first year at the school, a record that he would extend to his entire four years there, a feat that only one other BELL student has ever achieved. True success, of course, requires far more than simply showing up, even for a student to whom academics came easier than to his BELL peers, as Ramon would ultimately learn.

Some of his teachers started to worry about him during his second year at BELL. At that time, the school's early grading systems and policies were such that very little homework was assigned or completed in most classes, and the pacing of new content in the Junior Institute classes was slower and more deliberate than would have been optimal for Ramon's learning. With nearly three-quarters of his peers unaccustomed to full-time schooling (and not adapting to it as quickly as Ramon), and many had been in overcrowded classrooms where limited learning took place, it took a long time to get through language objectives and even rudimentary, upper elementary or middle school-level content. As all students were grouped together in all classes, regardless of prior academic exposure or academic or linguistic skill level, it was easy for students who caught on quickly, like Ramon, to sit back and receive accolades for his sharpness without much investment on his part. He delighted in helping others, but a concern arose that he was becoming too acquiescent in his approach to school, always showing up but not taking

charge to challenge himself. He just seemed to coast through his courses, often achieving the highest scores on class assignments without appearing particularly invested in the tasks at hand.

All was not well, however, inside Ramon's head, as he grew frustrated as he and his classmates started sitting for, and often failing, state exams that were required for earning a high school diploma. Most of the administration and staff of BELL's early years detested standardized exams such as these, in these early years instead trying to develop a more humanistic and holistic approach to education that often did not involve much in the way of formal quizzes or exams, externally developed or even teacher-made. During the school's first year, the state exams were barely ever mentioned, but that started to change during the second year and would change quite a bit as time progressed at the school. The prevailing model for test-taking at BELL and schools like it was to have students sit for the exams early, while they were still in the sequence of a given course, as a method of practice – seen as more tried and true than practice tests – to build momentum by seeing a few students pass with at least the minimal grade of 65, and others getting close to the hallowed 65 mark. The tendency was to go with the flow, with a prevailing sentiment among many students resting on the faulty assumption that they could pass the test if they took it a few times and were lucky on the last of these occasions. A large majority of students who sat for each exam failed it during that second year, and with a student body anxious to be out of school with their age and outside responsibilities, and a faculty maintaining that they were preparing themselves to go to college, things quite reasonably did not sit right with Ramon.

One characteristic that Ramon and a critical mass of his classmates had going for them, which somehow seemed to fade in subsequent class cohorts at BELL, was a sense of urgency by spring of their 2nd year, and continuing on through their 3rd year at the school. They wanted to be

out of high school as soon as possible, feeling the competing demands and desires of work, of not wanting to spend more years in high school, and the uneasiness in social settings of being in high school at age 19, 20, or 21. No one really knew in the early years how long it would take to earn a high school diploma from BELL, as there was no other school like it. Without anyone who came before them at the school, Ramon and his peers would set the tone and blaze the trails of possibility, and just as importantly set the achievement ideologies, for years to come at the school. Unfortunately, many of Ramon's peers from his first year at BELL, including the majority of the boys, would ultimately leave prior to earning a diploma, even as the school poured its teaching, counseling, and administrative efforts into helping to support these students toward graduation. Like most of his classmates, Ramon seriously considered giving up and looking for work, and maybe trying a GED, in lieu of a high school diploma or college education, but instead he chose to keep his perfect attendance record going, which would pay dividends for him and to many of his friends and classmates whose future he would help to shape in the years that followed.

The third year was a critical one for Ramon and many other students at BELL, when their sense of urgency came to a head along with efforts from the school's teachers and staff to accelerate their learning and the development of their habits of work and mind in preparation for success at the college level. A more formal grading system was put in place, a Homework Club started three afternoons per week, and with many students "bought in" emotionally and socially from the school's first two years, some teachers significantly upped the antes around the academic demands and pacing of their courses, introducing a paradigm of high expectations coupled by high support that would be necessary in order to move students toward graduation, and certainly to improve students' chances at enrolling and succeeding in college.

By the spring of his third year, Ramon had a penchant for spending long hours after school – he and a number of his peers truly enjoyed the safe, relatively quiet space of a couple BELL classrooms – mostly helping others with their homework, but it took considerable time for him to feel a true sense of urgency to further his own learning. This issue first came to a head within a couple months of his junior-year chemistry class, in which I was the instructor, and the first course that Ramon and his peers had taken at BELL that required frequent problem sets and the regular use of a textbook. Ramon and his peers knew that in the local schools attended by their cousins and other family members and friends, students were only required to take a state science exam in biology or earth science, and that college-prep chemistry courses following state standards were few and far between in such schools.

To BELL's knowledge, no other members of its network of newcomer ELL high schools were requiring this course and accompanying exam of its students. Ramon and a number of his friends and acquaintances took exception with the teacher's and school's insistence on their completion of this college prep-level chemistry course. They saw that it required significantly more practice and quantitative skill-building than the Regents-level biology and earth science courses of other schools, and that the exam was graded far less generously (i.e. required performance to achieve what the state defined as a "passing" score) than these other exams, or than the sole math exam (Algebra I, with a "cut score" of 34% defined as a 65) that they were required to pass toward earning a high school diploma. Ramon complained openly about the class's demands, which included more quantitative exercises than were assigned in math class, and the fact that they were compelled to take this chemistry course, which included thematic unit projects around high-interest real-world problems, in addition to the problem sets, quizzes, and

exams, to integrate and extend student learning. At one point, Ramon and his peers threatened to formally protest the course to BELL's principal.

As the course's developer and instructor, with an eye toward developing talent in the so-called "hard sciences," I would frequently engage with Ramon and some of his peers in reflective discussions, or what Emdin would call "cogenerative dialogues" (2010), in class and after school. While listening to Ramon's point, the instructor would respond by asserting time and time again of the necessity of the course, and reminding Ramon and other students of the supreme utility of chemistry, the central science, for a variety of current and future purposes, and as a ticket toward future opportunity. Furthermore, it was the instructor's expectation and belief that the students could master chemistry and continue toward pursuing a STEM-related field in college, and this belief and its consequences were not going anywhere. Ramon relished opportunities to lead his peers, and he enjoyed spending time in my classroom, talking about homework, his future, basketball, and other topics. Within a couple months he would become a vital lifeline in the classroom and after school, taking an active role as a co-teacher and leader of his own study group, which even had its own rules and structures.

The early battle with Ramon was one that would continue with some students throughout the year, but Ramon was buying in more and more, and he brought a number of his peers with him. He started his own young men's group in my classroom. They met two to three times per week for a couple hours after school. He commandeered a mobile chalkboard, behind the table where Xiomara's home base was centered and diagonally in front of the sofa where Xiomara's friends and others would relax, often enjoying a chicken *pastelito* or two. Ramon and his crew had a name for their group, and they had a set routine consisting of alternating periods of working through homework problems together, often with Ramon at the blackboard in the

teaching role that he so loved, and shorter bursts of physical activity, mostly going for a run outside the school since BELL's access to gym facilities were limited to two afternoons per year. (These were the two afternoons when Ramon would organize a school-wide basketball tournament and permit me the formal role of coach, albeit without much input and never with the opportunity to be player-coach. While the instructor/researcher and Ramon shared responsibilities after school in the classroom, an invitation to play ball with him and his friends would not happen until the Thanksgiving following his graduation.)

The students would eventually design and write their first-ever research paper in the class, but such an endeavor was not overwhelming to Ramon and his peers once they had become accustomed to the level of expectations, and the teacher and peer support that would come with it. Ramon and his peers would spend hours upon hours on their problem sets throughout the year, even at one another's homes or local libraries during vacations. Ramon would also secure one of the last spots offered by the instructor for a paid summer research position, in his case in a chemical engineering laboratory at City College. Ramon's goals shifted over the course of the year as he came to use the back of room 464 to urge others to be their best, especially in chemistry, by far their most challenging course, and he would routinely stay in the room well into the evening hours with the instructor. From a goal of finding a way out of this challenging chemistry course in October, by spring semester Ramon's new goal was staying as long as possible in his second home, room 464, challenging the instructor and himself to occasionally stay until 8:00pm or later, working on problems, talking about life and his future, and more.

While Ramon enjoyed science, his two true loves were math and helping and teaching people, and following conversations with me and others during his senior year at BELL, he

decided to pursue a career in mathematics education. "I love to help people, and the best way I can help students succeed in mathematics is by being a math teacher and a role model for my students." Moreover, when a BELL teacher went on maternity leave during his senior year, he had helped take over some of her 9^{th}-10^{th} grade math classes twice per week. Ramon is perhaps the epitome of a social learner. A pattern that would recur in Ramon's life, his successes seem to be intimately coupled with Ramon forming strong social ties to instructors and peers who would serve as his learning partners, and with his ability to take leadership roles related to his love for helping and teaching others.

Manuel: From Peer Groups to Lucrative, Hands-On Careers

Manuel was one of the students who joined Ramon's after school young men's study group, but this was just one aspect of his path toward STEM, and to staying in school overall. He arrived in the US from the Santo Domingo, Dominican Republic, with his older sister, who joined him at BELL, as well as his younger sister and their mother, after they had spent one year in Puerto Rico with their grandmother. Like countless teenage boys in the Dominican Republic, Manuel's childhood and adolescence up to that point had been dedicated predominantly to playing baseball. He was a solid ballplayer and overall athlete with incredible speed, and he figured that his plan would be to continue playing in hopes of signing a professional contract. On the surface, by being in the US, it would seem he had a leg up on the dream he shared with his peers back home, where many Dominican boys would be recruited to live in Major League organizations' camps and the most talented would be signed and then get a ticket to the United States (albeit to play with a minor league team), with about a one in thirty chance of making the big leagues.

Many of Manuel's early friends at BELL were other Dominican boys with similar pipe dreams, some of whom had even left school and family to try to "make it," albeit unsuccessfully. Manuel would provide a window into this cultural construct for me, his science teacher, over the course of his years at BELL, starting with that first of many visits to the family's 173rd St. apartment when his sister gave birth to her first son. Manuel and his friends were frustrated to find that they could not join a school baseball team, as BELL did not have a team, and the building-wide team (representing six schools) seemed to give them the runaround, even those who had not yet aged out of playing high school sports. Some of the boys joined teams in their neighborhoods, but Manuel never found a new coach and team to be his second home like in his native DR. A future doing something other than baseball had never before entered Manuel's mind, but he needed other plans, hopes, and goals to latch onto, and he would come to find them at school, even as nearly all of his friends from his first semester at BELL would drop out within a couple years. In the classroom the first year, Manuel, like nearly all of his peers, had a lot of difficulty suddenly having people talk to them in English for over six hours a day and to complete work with instructions and readings in English. His teachers noticed that he seemed relaxed, at ease, but also without much of a sense of academic direction or urgency, and he was slow to open up to discuss anything beyond the superficial.

I came to know his family over time, although his older sister, who seemed far more interested in and accustomed to "doing" school, left within a few months, struggling to juggle child care needs and then finding a new boyfriend, with whom she would soon have another child. Manuel's mom wanted the best for her son and tried coming to BELL parent nights whenever possible but, like many BELL parents, relied upon the school to help show the way and pave a path as she was not familiar with navigating the world of higher education, let alone

the complexities of higher education in their new country. While maintaining the cool outer veneer typical of teenage boys, it was clear Manuel wanted to make his mother proud and, though he did not like to admit it, serve as a role model for his younger sister as well. I considered it a major "win" when in his senior year at BELL, Manuel finally broke down to talking about his feelings of abandonment by his father, noting that he needed time to really trust someone to talk about this sensitive topic, just as he also needed to feel a deep sense of trust to reach out for advice or to discuss his future goals and options. (His openness would admittedly carry a different tone and quality than, say, a student from a more rural Dominican background like Luis or Maria, whose families would host me in their towns, as described below; Manuel's response to my interest in the Dominican Republic was, "My hood back home was a lot rougher than E. 173rd St., and if a guy like you were to come visit, you should expect to get robbed.")

Manuel had started hanging out with the group that would coalesce as the "six pack" his first and second year, and after he started going out with Xiomara (also part of the six-pack), he started showing more interest in school. If Manuel provided me a window into understanding the complex lives and great potential of BELL's Dominican boys, then the seven members of the six-pack – alongside Ramon's boys' group (with Manuel and JAM as the two overlapping members) provided a window into understanding complex social culture and dynamics of a cohesive Latino/a friendship group and the profound impact that peer pressure can have in fundamentally altering the trajectories of students' futures. Xiomara and Angela were by far the most academically engaged members of the "six-pack," and as an extension of their own dedication to spending long hours after school on their homework, Manuel, JAM, and the others followed suit, getting a lot of homework help along the way. Another teacher and I would joke that Manuel should wake up every morning and give thanks that Xiomara came into his life, but

there was something quite serious about his performance at BELL that seemed intimately tied to the hours sitting with Xiomara and the others, sometimes working and sometimes just hanging out. Whether it was homework at school or over a chicken dinner, or taking a running break with Ramon's group or hanging out at someone's apartment or a Dominican parade with the six-pack (and sometimes me), Manuel had found like-minded peers who had earned his trust and helped challenge him and reach greater academic heights than he had been aware of when he first came to the school.

In terms of his future, Manuel had experience fixing bicycles and other mechanical objects and was interested in how computers and electrical systems worked as well. Inspired by a curiosity of how things work and hearing about good salaries in the field, he wanted to pursue a career in engineering. He looked back fondly, if a bit uncomfortably, on baseball, as he would write in his college essay that it occupied just the first few "innings" of his life until life threw him a number of tough curve balls. He did not want to reach out to his old baseball coach back in the Dominical Republic, who seemed to have been an important influence in his early teenage years, because he thought he would be judged negatively for deserting the baseball world for different, educational pursuits.

Manuel realized from taking a couple college courses in engineering design and web programming on Saturdays during his senior year, as well as an earlier internship that he and JAM had found boring, that he was less interested in computer software than in the more hands-on world of electrical or perhaps mechanical engineering. Looking back, the core group of guys who remained his friends were nearly all interested in STEM fields, including computer systems, engineering, forensic science, architecture, and math. Academically, most of them had grades similar to his low-B average (some with more of a mid-B or a C+ average), were also drawn to

their STEM interests largely by hands-on experiences (often outside of school) and the lucrative nature of high-tech careers, characteristics that would remain remarkably consistent for nearly all of the Latino young men in later cohorts who sought to be part of the STEM pipeline.

Maria: Classrooms and Projects that Value Students' Funds of Knowledge

Maria's interest in science was rooted in practices of the family rice farm in the Dominican Republic, but the interest and curiosity around these practices and knowledge would ironically be sparked by experiences in science classes following her move to the United States at age seventeen. The Bronx was worlds away from the village of Bomba de Cenovi, plus the physical distance of fifteen hundred miles, the latter seeming less significant to me when I had the privilege of visiting Maria's family and their rice plot while visiting the Dominican Republic with another BELL alumnus's family.

Maria would later reflect that she started thinking seriously about a science career after an experience in my chemistry class during her junior year at BELL. Maria and her peers (including JAM, whose project was also inspired by his experiences "back home" as related above) were developing a research question and writing a paper about an issue and contaminant of interest to them, as described in chapter 4. Maria liked telling her teacher about her grandfather back in the Dominican Republic, whose intrigue among other things involved a lack of insects and other pests around their home and rice farm. She was curious about the chemicals that her grandfather and father used on their farm and decided she wanted to learn about the science behind the fertilizers and pesticides. Maria knew her family used these products and deeply admired the experience and knowledge that her father brought to his work, but she knew that as her parents had stopped attending school in junior high, they had never had the opportunity to explore the chemistry behind the products they used on their land. She found that

the experience of doing this research project – where she wrote a policy memo that explored the chemistry of glyphosate, the active ingredient in Roundup, as well as its negative health effects and the most effective methods for removing it from a water source (chlorination and ozonation) – helped her see the intimate connectivity and importance of science to her prior knowledge and sparked her interest toward studying science in college.

For this anecdote, the style will switch to the first-person narrative style of the previous chapter to more fully relate my experience of spending part of a week with Luis and Maria's extended families in the Dominican Republic. Given the nature of this research and the importance of being able to provide the reader a robust, comprehensive understanding of this particular experience because of its value to the larger research project, it was crucial for me to engage in a critical autoethnographic study (Boylorn & Orbe, 2013) of my short time in the Dominican Republic. This is not to say that the entire work takes on a critical autoethnographic lens, but rather to employ a research framework that allows for deconstruction of this poignant experience for the purpose of ensuring that the reader understands its significance, that I clearly articulate the nuances of the experiences, and that it becomes clear how this experience influences the work moving forward.

I mentioned being deeply intrigued by context and the remarkable lived experiences of our students, whom our principal would, on momentous occasions, commend and encourage in awe for their strength and "years of things that go beyond what most of us will ever experience." Through the conversations and visits to various neighborhoods and homes, learning from students about Dominican and Central American cultures, various West African political and tribal issues, and current events in Bangladesh, from time to time students would mention that I should visit their home countries. I have rarely used a passport but decided after the first BELL

class graduated to reach out to eight of my former students from the Dominican Republic, the most heavily represented country at BELL, and asked if any of them wanted to show me around their old neighborhoods during the following winter break, after their first semester of college.

Luis, a young man who was Maria's boyfriend and who had always been a high-energy student in my science classes even as he struggled mightily with understanding the material as well as with writing and focusing while sitting down for long periods of time in school, enthusiastically responded that he and his family would love to host me during the week of Christmas when he would be visiting them anyway, and we could also go to Maria's family's farm a couple hours away. I knew his family to be very hospitable, friendly, religious Catholics, and I discussed with him the strict religious dietary laws that I keep such that I would not be able to eat most of their food, other than fresh produce and coffee, and did not want to offend anyone. Luis reassured me that everything would be fine and that everyone would be comfortable. Excited by the chance to be immersed in Dominican culture (and the Spanish language) with my own personal guides to gain a deeper sense of the environment and cultural fabrics that shaped my students' upbringings, I booked a ticket to spend part of Christmas week 2012 in the Cibao region in the northern Dominican Republic in Luis's hometown of Guatapanal and Maria's farming village of Bomba de Cenovi. Selections from my daily observations are below.

December 24, 2012. Christmas Eve, Noche Buena, one of the most important days of the year for Dominican families. Luis and his Tio (uncle) Nelson pick me up at the small Santiago airport, located near Licey al Medio, home to a famous Dominican baseball team and several BELL students. There is a pistol on the passenger seat as I open the door to get in. They move it and tell me not to worry, that it's just there "because he (Nelson) is in business" selling dry goods, so he has to have a gun. We drove in their Chevy truck, which had flipped over months

earlier while carrying Luis's father, into the city of Santiago to see Nelson's extended family, passing the bodega where Luis had worked when he was eleven. We tried to buy some fruit, mostly for me to try some local selections, but a lot of stores were closed for the holiday. After an aunt loads the truck with things for us to take home to Nelson's store in Guatapanal, we start driving to Guatapanal, the town where Luis's extended family has lived for generations. On the way, we stop on the road where a couple guys have a fruit stand, and they insist on treating me to a freshly peeled papaya. After driving past lots of banana trees and pineapple plants, the latter of which had to be pointed out to me, we arrive in Guatapanal. We unload the truck together at Nelson's store, and the unloading is approached like a game to make it go faster. Then we go to Luis's grandparents' house. Next to it is a barn silo and then an aunt's house. They give me the master bedroom, by far the nicest room in the house. I notice some of the rooms don't have a ceiling, but the whole house has a piece of what looks like corrugated aluminum on top as a roof. I feel like a king the way they treat me here!

I put my suitcase and backpack down, including a bag of pretzels and other snacks to subsist on along with the fresh produce, and a pot in case I want to prepare some kosher rice and beans for myself. After that, we go outside, I hold some ducks, one of my favorite animals, and there are chickens and a turkey outside the house as well. The silo has many 125-lb bags of rice inside, and there is a very thin, small cat with a string around its neck that walks through. I nap and pray my daily afternoon and evening prayers, and then the family returns home from church, with their discussion of the new pastor and his style reminding me a lot of synagogue politics in Jewish communities that I am familiar with in the US. Luis's dad comes home later, after 10:00pm, from his job nearly four hours away in the capital. Together the extended family has a house together there, too, and a lot of people go to the cities to work during the week

because there are not many jobs, or services like hospitals, in small towns like this one. The family says grace and a song about Mary that reminds me of how my friends sing religious songs, zmirot, at our festive meals. Then there's dinner, lots of homemade food from the aunts. About twenty-five family members pack into the house for dinner. Papi, the grandfather, is lying down for most of dinner, and I learn that he has a total of twenty-two grandchildren. An aunt prepares a plate of fresh vegetables and pineapple just for me. We eat and then hang out inside, and then outside in the cool night air. At 12:15am we are sitting together on the patio drinking small cups of coffee – I learn you drink a small cup of coffee at night here, at least when socializing – and we talk about baseball and other subjects. There seems to be no internet access here. Two aunts and uncles are on the phone from New York City, and the phone is passed for me to talk with them. This first day was so different than my regular world in the United States, and my Spanish is carrying me OK.

December 25. At 6:00am, Luis and I walk in the pitch darkness to the dairy cow pasture nearby, jumping over some small wall or barrier. We hand two cups to the man milking the cows, and in a moment he gives us back the two cups, with fresh milk inside. It is very muddy around here, but it is also apparent that this is not just mud. Before milking each cow, one calf is released and gets a little milk, to make the milking easier. I wonder whether the calf chooses which cow will be next for milking or if there is some process that the milking guy uses to decide who is next. After milking, we go back to sleep for a while. Then I wake up, pray, and have breakfast: a carrot, peanut butter, raisins still attached to the grape stems, coffee, and five small bananas. Luis knows like everyone here; we walk into random neighbors' houses and are greeted by longtime friends of Luis. Many of the houses are made of wood, are very small, and some don't seem to have windows. The neighbors know Luis's favorite dish is arroz con

gandules (rice with pigeon peas), and a lot of people keep large pots of food around for family and friends who are passing by and serve him some arroz con gandules. I also get a fresh green pomegranate straight off the bush from one of these neighbors. Sharing among friends and neighbors (terms which seem to be synonymous here, even across social class lines), takes on a different and far more communal feeling here than in New York, or even than smaller city and town settings than I have seen in the United States.

After meeting these local friends, we go to the local Titin Minaya ballfield for the annual Guatapanal baseball tournament. There are three teams representing the three neighborhoods in Guatapanal: Arriba, Abajo, and Barrio. Luis's family lives in the northern part of town (Arriba), but Tio Nelson and cousin Fernando play for Barrio. After the first game, we come home to relax and get some fruit from outside the house. Luis climbs on a ladder to cut down coconuts for us to snack on coconut water. He cuts some open and then passes me the machete, and I get one open after several hacks. Papi cuts one open, almost artistically. I also try a fresh sour cherry and Papi cuts off some guavas for later. We arrive at the 2nd game in the top of the 5th inning. The same pitcher actually started both games for Abajo and pitched 10 innings, surrendering 19 runs! It is getting dark, and after the ballfield lights go on and off intermittently, they ultimately shut off and will not come back on. We drive around in the truck to find a generator or something to help with the light situation, but eventually they decide to just postpone the tournament and its final game. During the games, there are municipal police present to help maintain order along the sides of the field. An aunt and uncle of Luis are among this local police force, which I learn is a group of volunteers. They interact naturally with the fans in the stands, who are their friends, neighbors, and family members. I figure they are present to help avoid any unsafe situations that may arise from the tall glass bottles of beer that

are sold for 40 Dominican pesos ($1US). Overall, these municipal police seem to be mostly in name only, and are nothing like the state police force that we met when driving to Guatapanal who had blocked the road to ask us, and certainly others before and after us, for money, backing it up not with a traffic offense but by saying something to the effect of, "Hey, it's the holidays, and we're the police and we need money, so come on, how about 1000 pesos?" After the tournament was called for darkness and light malfunction, nobody seems all that upset, and we end up speaking with a Dr. Minio, a pretty young guy who is the town's dentist. He is very friendly, mentions he has family members in the US who are well-known dentists near East 149th Street in the South Bronx, and he repeatedly asks me to get in his SUV so that he can take me for a ride to see his beautiful country, maybe meet some women, etc. I repeatedly refuse, become uncomfortable, and am very happy when Luis rescues me and we leave. We stop on the way home for Luis to enjoy a plate of food at a friend's house, a guy who is a few years older than Luis and lives with his wife and children in one of the tiny wooden homes that does not seem to have windowpanes. Then we come home, and I make fettuccine alfredo, and also serve the kosher New York Jewish pastries that I brought on the plane, to Luis and his extended family members. Between the cow-milking and baseball and other events of that day, I enjoyed talking with two of the aunts as well as Papi, and the aunts openly mentioned to me that they were enjoying the opportunity to get to know a Jewish person and someone from such a distinct culture than their own.

Seeing how I was enjoying all the local produce, after trying my first ever guava, an aunt asked if I wanted some lemonade, and we went outside and found a lemon, squeezed it, and added brown sugar. Guatapanal, like Cenovi where we would be going the next day, were not places that generally saw any tourists. Anyway, the family likes the alfredo dinner, and I eat a

papaya, a guava, and some of the rugalach that we all shared. Over dinner, I continue talking in particular with one of the aunts and cousin Fernando, a first baseman for Barrio who is seventeen and interested in a medical career. Papi is upset that Fernando and the other boy cousins did not come back from hanging out at Tio Nelson's until 10:45pm. I am told I resemble a cousin from Santiago, and this almost gets me hit as some kind of practical joke by a neighbor in a motoconcho while we were walking on the streets in Guatapanal (where falling into a ditch is extremely easy since there are huge ditches (with no metal grates or other cover) for some stretches separating the road from the roadside grass. I am also told that I am part of the family, and people keep telling me that I must come back to visit for a full week or two in a future summer. I like it here – the fruit is great, the people friendly, the nature beautiful. I am beginning to understand where Luis's great social intelligence comes from.

December 26. I wake up and eat more fruit for breakfast after morning prayers. The two foods constantly available in Papi's kitchen are the basket full of small bananas and the refrigerator full of well over 100 carrots. I wonder whether there is some sort of cultural significance to these carrots that I had missed, but Luis's family tells me they have no idea what the deal is with these carrots, that Papi must like them a lot and that he does not know how to keep a kitchen going when his wife (Mami, as she is affectionately called by her children and grandchildren alike) is visiting her daughter (Luis's mother) in the Bronx. Today is the day that Luis is taking me to the beach and then finally to meet Maria's family on their farm. Luis, his older brother Eddie, his fiancée Pamela, and I travel north together in the truck to a beach in Puerto Plata. We stop for gas and I pay for a fill-up. Gas is 231 pesos/gal, which is nearly six dollars per gallon with the current conversion rate of roughly 40 pesos/US$. Everything else seems so cheap here, but the gas is so expensive. Maybe this is why Papi keeps a big tank of

diesel behind his house, which he uses and also sells to others. (I was expecting the tank that I saw on top of the house, a tinaca for collecting rainwater, but I did not expect to see a home diesel tank.) Once we figure out payment at the gas station (they tell me I should be able to use my Discover card, but after ten minutes I realize they have never heard of Discover cards before), I pay $100 in lieu of 4000 pesos (they finally let me pay for something), and we continue on to Puerto Plata, where we park and they look for a beach so they can provide me with a true Dominican beach experience. I enjoy a swim there and then Eddie helps me find a place in the adjacent shopping mall to inconspicuously change clothes and wash off the sand. Then we go to nearby Maimon, Puerto Plata, the nation's fish capital. I catch my first sight of tourists while in Puerto Plata, and they tell me people on vacation from places like Europe come and enjoy the fish here. They sell and cook many kids of fish here, high-quality and no-frills. There's tilapia, salmon, and at least six more fish to choose from, as well as different sauces and preparation styles, none of which are familiar to me as a vegetarian. Between Luis, Eddie, and Pamela, they get three whole fish with fries and a 2-L bottle of coke, and it is all just 600 pesos ($15US). Then we stop on the street so I can buy some fruit to eat. We buy a mango, six mandarin oranges, and four bananas all for the equivalent of about $1US. The mango is soft, fantastic, one of the best things I have ever tasted.

Then we drive southeast, through the outskirts of Santiago and the carnaval capital of La Vega, to Bomba de Cenovi, 15 km outside of the city of San Francisco de Macoris. Bomba de Cenovi is very small and does not seem to have a lot of people. It's basically two streets, one of which goes on, north-south, for over ten miles, surrounded by rice paddies, which look especially beautiful now as the water reflects the setting sun, with green stalks poking out from the surface. (This landscape would become my computer background screen, which it remains today.) We

get to Maria's family's home. It is the home where her mother grew up, and where her mother (and sometimes her father) and her grandparents continue to live. It does not look like a regular house. There is a little kitchen building, a shed, a modest house, and another smaller structure. There is a little boy neighbor, maybe four years old, with a broken bike who is running in and out around the yard throughout our evening there. I ask for a tour of the family rice farm. It is a peculiar request for anyone to hear around here, but Maria's dad says it's fine and patiently drives to his plot and walks around there with us as I ask him questions about how rice farming works. He is a farmer, his mother (who now lives in the Bronx) owns a lot of rice farm land, and his wife's parents with whom he now lives were rice farmers, or rice producers as they were also called. I learn that there are two rice harvests per year, producing 350-400 huge sacks of rice that he sells to a company that will process it (removing the shells from the grains) and then market it. Along the side of the family rice plot, they grow beans and yucca for their own consumption, and I realize that this family is more self-sufficient than anyone I have met in my life. I also wonder about the deep funds of knowledge that he and his family have accumulated over the years and how they can be accessed in the Bronx, like in learning science, in the workplace, and beyond. When he moved to the Bronx (he would spend more and more of his time there after 2012), he would work at a supermarket and then as a hospital custodian, and it seems like the Bronx is just such a mismatch in terms of being a place where all this farming knowledge goes idle.

We return to the house, and I say my afternoon prayers outside, where there is also a large pile of sticks with a chicken sitting on top of it. Maria then escorts me to the dinner table, which is actually outside, behind the house and next to the detached kitchen room, and she seats me at the head of the table opposite her husband. I knew how Maria admired her grandparents

from her referencing them, especially her grandfather, multiple times when she was my chemistry student and advisee, and now here I am eating dinner in their backyard, in front of their coconut trees. We speak briefly with Maria, who is in the Bronx for winter break from college and tells me for the first time that she is thinking of becoming a science teacher, on the landline telephone, but now it is time to eat. These people are treating me so special just like Luis's family, and with Luis explaining my religious dietary restrictions to Maria's mom and grandma in advance (the grandfather was puzzled about my eating only fruit, and seemed to be joking with me about it, but my Spanish was not good enough to notice that he concluded with a compliment when I thought he was teasing or disapproving), they have prepared a special plate for me. My dinner plate has five bananas, a large papaya, and an entire cantaloupe and pineapple. Maria's dad and I have a conversation about baseball, and the economics of professional baseball, and other topics. We go from talking about Canada (I explain that it is a country, as he did not seem to realize this) to conversations about regional dialects like the Pittsburgh accent that I have lost in speaking English in New York over the years, to my own father. He enjoys hearing me describe the manhole cover business that my dad and his family have worked in near Pittsburgh for decades, and he says he would like to visit Pittsburgh. The grandmother is very quiet, and she and her husband, as well as Maria's uncle who is present, do not actually eat anything. Maria's mom eats at a small corner of the table, which reminds me of how my mom squeezes in to eat dinner at my house when we have guests and she has been serving everyone. We have coconuts for dessert after Maria's dad cuts them open effortlessly with one hand. They insist on me eating or taking coconuts, or at least the water, with me. We take a combined family photo – inside the house are a couple individual portraits, but they are actually paintings (made by a family member, and not looking exactly like the actual subjects) –

and then we leave Cenovi before 8:00pm, but not before the family tells me that I am always welcome in their home. We stop in the city of Santiago at a famous monument, where little elementary school-aged boys as well as men are selling horseback rides. Luis and Pamela each take a ride for a bit, and then Luis has an argument with the little boy about how much he is demanding to be paid for the ride. I do not like it in the city, much preferring the campos, so I am happy when we go back to Guatapanal, where I feel comfortable and at home, if a bit disconnected from technology and the outside world. We go to Nelson's colmado (as bodegas are called in the DR) and I buy 8 packages of coffee and 4 lb of rice to bring back to the US. I had wanted to buy rice from Maria's father – when else could I buy rice directly from the man who grew it – but he explained that I could not buy and carry unprocessed rice back into the US. Then we go to Nelson's house, which I realize is where the cousins like to go and hang out whenever they are around and have free time, as Nelson seems to be the de-facto "cool uncle" of this extended family who loves his kids and nieces and nephews coming over and hanging out and talking together, not caring about noise or the late hour. Nelson embraces and is a part of it, in fact, clearly spending a lot of time with all these kids, and Luis even refers to him as his second father. We watch Nelson and his wife's wedding video, which keeps freezing on the computer screen, and even hear about the first night they ever spent together. People are really open here, but granted, they have told me that I am part of the family, so I guess it is about that trust element, too.

December 27. At breakfast, I have my morning coffee and breakfast, bringing my banana total to seventeen in seventy-two hours. When I walk in to the semi-enclosed room where I eat breakfast, a chicken is on one of the other seats and squawks at me. I see that the egg in the nest atop the armoire next to the table has hatched into a baby chick, and I hold it for a little while.

Then I say good-bye to the house and Papi, and Luis and I drive to Santiago with an aunt, two cousins, and a cousin's friend (some of the guys are sitting in the flatbed portion of the pickup truck). We drop off the aunt at the bank and visit another aunt at the medical clinic where she does intake work and draws blood samples. She and another aunt also present me with parting gifts! Then we go to another friendly relative's house, and I see a computer with internet for the first and only time while I am in the DR. One of the cousins adds me as a Facebook friend. They give me more fruit to eat and I talk baseball with the cousin's friend, who is an aspiring ballplayer. We stop at a market with little shops where I can buy souvenirs to take back to the US, and after I compliment the cousin's friend on his cool sunglasses, he refuses to leave the topic until I accept his shades as a gift. (The only person I have ever seen with this kind of shirt-off-your-back hospitality with guests is my own mother.) Finally, I am dropped off at the airport and say good-bye to Luis and the others.

I recognize that the chain of events that led me here are quite unusual, to say the least. I wonder about what life was like back in the DR for other families I know from BELL, and how many had lives here that were similar to Luis's. I also wonder about people from the campo, from the countryside and farmland, if I can generalize some habitus about them and the way that some of them seem to understand science easier than those from non-rural environments. Is there something to this, or is Maria and her interest and talent part of her being a diamond in the rough?

Maria's experience, which became far more fully contextualized for me when I visited the Dominican Republic and her family's farm, evokes discussions of the importance of "funds of knowledge" (Gonzalez, Moll, & Amanti, 2006), activation of students' prior schema, culturally relevant pedagogy (Basu & Barton, 2007; Ladson-Billings, 1995), and the valuing of

indigenous knowledge (Emdin, 2013) in creating learning opportunities for students to latch onto to catalyze interests and abilities toward pursuing STEM careers. Indeed, a few other students mentioned experiences within a science or mathematics course, at BELL or in their native country or even their freshman year in college, that was instrumental to the development of an enduring interest in STEM. These inspiring course experiences, often rooted in an instructor who made a course particularly enjoyable and developed a close advising or mentoring relationships with the student, and/or in work that connected to students' lives, thus emerged as another theme in understanding the way BELL students started on the path toward higher education in STEM.

With a thoroughly contextualized understanding of how various BELL students entered the STEM pipeline from their early life experiences and their time at BELL, the next step is to follow them through the experiences that mediated and shaped their transitions to college, and then their college experiences. Throughout discussion following Phase I student interviews, and following from the prior literature (Tsui et al, 2007) as well as my own experience working with BELL's first four cohorts of students in their transition to college, it became apparent that mentoring relationships, extracurricular STEM enrichment and outreach activities, and BELL's unique college access and success approach must be examined on the way to describing the students' paths once they started college.

Chapter 6

STEM PERSISTERS AND SWITCHERS: SHAPING THE TRANSITION TO COLLEGE

CHECKING IN: ORIGINAL, PHASE I STUDENTS IN COLLEGE

This chapter continues following the BELL students through their current point of progress through college, now as either STEM persisters or switchers. It attempts to document and parse out some of their struggles and successes from their last year in high school, where the last chapter left off, through the crucial transition to college and through their college career to the present (between their first and fourth year, depending on BELL graduation cohort). First, the paths of the four original Phase I students (who are also part of the larger investigation) are revisited.

Mamady majored in pharmacology at a flagship public research institution, crediting the unique circumstances of his upbringing, including the long-term separation of his parents and subsequent early learning of independence, as part of his path to success. At every step along his path from Guinea through ELLIS and then into and through college, he has also demonstrated an intriguing propensity to find like-minded students (and now pharmacy professionals) to push each other and provide additional motivation. The formation of study groups, and from these, learning communities, has become routine for Mamady, who at the same time has historically had to rely on himself as his ultimate motivator, with parents who were not really educated and did not really encourage his lofty educational aspirations. On the other hand, Mamady has also become quite adept at adopting near-peer mentors who are slightly older than he, to help lead him to the next steps toward his goals.

Regardless, it has become apparent over the past six years that while financial difficulties present formidable challenges to Mamady at times, he remains for the most part unfazed by any academic challenges, simply working through difficult material and classes with the belief that he is capable of success even after, as he would say, "things got real" in competitive science classes with excruciatingly low exam averages around students who were not only native English speakers but who also had broader high school preparation in the sciences and beyond. In May 2015, he graduated with his Bachelor of Science degree, BELL's first student to graduate from college. His mother and I were in the audience, but he did not "want to make a big deal" of the graduation because his grades had not been as high as he had hoped and which he figured his mentor (me, in his case) was expecting of him. He was admitted to one graduate program to pursue his Doctorate in Pharmacy, but is instead taking the year to work and re-apply to get into his number-one graduate school choice.

Aissatou is now finishing the final semester of her Bachelor of Science degree in Nursing at a small women's college that had awarded her its largest merit scholarship. Aissatou continues to hold herself to high expectations, even when taking classes in her fourth language (English) in areas far outside of the knowledge she gained from her time at BELL and back in Senegal. She also has a minor in Psychology and has worked as a peer tutor in psychology and chemistry on campus. Aissatou continues to generate and thus experience a positive environment around her, seeing her college professors, classmates, and friends as helpful and supportive by default, nearly never even acknowledging, let alone blaming, any external factors for any difficulties she encounters. She has found the language and work in college to be overwhelming at many times. Aissatou also recognizes feeling nervous or self-conscious of the way she expresses her questions to her professors, based on the way they respond to her.

She is looking forward to zeroing in on the sub-field within nursing where she wants to work as she completes the last of her rigorous clinical coursework and hospital placements. Her GPA of nearly 3.5 in one of the most competitive and highly-structured programs at her college makes her one of the strongest performers of any of the BELL STEM persisters in college, but she expects better from herself; for the first time, this year she admitted feeling like she was "okay" with the grades she was getting now, feeling grateful that she is nearing the end of her degree because she has had about enough and wants to get into the field and get to work as a nurse once and for all. Her mother and her mentor are among the key people who she sees as pushing her forward, as people she wants to make proud, and she is now married as well (her husband has not yet been able to move from West Africa) but ultimately, her drive continues to come from within. She has not counted out becoming a Nurse Practitioner in the future, but for now, she looks forward to helping people as a hospital nurse and bringing her husband to join her in the United States.

Angela went on to attend one of the nation's elite women's liberal arts colleges. Angela talks candidly about the challenges of being a poor Latina young woman from an under-resourced, all-poor, all-minority public high school who is now attending an elite college – what media and some in academia have started referring to as the "doubly disadvantaged" (Jack, 2014). Indeed, even among her peers in her Opportunity Program, she observes that most of the other young women graduated from top-flight magnet schools or were scholarship students at boarding schools. Riordan's (2004) work on the significance of one's high school context and its relation with the relative level of academic preparation and capital that is available to students seems to blare out from Angela's observations of her own situation in college.

As a college freshman, she was advised by her Opportunity Program staff that she was not ready for General Chemistry on the basis of her SAT math score, despite having completed an advanced chemistry course at BELL (in which her performance did admittedly suffer as her family fought potential homelessness, among other challenges) and performing well in her Opportunity Program's summer chemistry class. She had loved chemistry since being introduced to it in El Salvador, fascinated by the ideas and concepts, and that continued at BELL. Through college biology courses, and then chemistry and chemistry lab, however, Angela's enthusiasm for science waned. It was no longer enjoyable to learn the material. Her closest friend on campus struggled in science and was advised to switch to fine arts, and her campus involvement revolved around a Latina student organization and other activities that did not capitalize on or especially value students focusing on science. She became thoroughly frustrated with what Tobias referred to as the "tyranny of technique" (1990), in which she (as some other students reported at other institutions) was thoroughly penalized each week for what seemed to her to be small errors in her lab reports. At Angela's college, students are actively discouraged from doing homework together in the sciences, flying in the face of research implicating learning communities for the success of diverse groups of science students (Graham et al, 2013; Rosa & Mensah, 2016). Furthermore, Angela feels put-off by most of the other science students and, at this point, does not view them as people with whom she would want to study. The professor with whom she felt deeply connected and showed a strong belief in her abilities is an English professor, who has pushed her to continue writing and to consider making this strength part of her future plans.

Based on her accomplishments in high school, from all of BELL's first four cohorts, Angela was arguably BELL's strongest student ever "on paper." After becoming stressed to the

point of getting physically sick in the sciences, Angela switched out of science once and for all, deciding to major in Politics and Human Rights. She arrived at her new majors, and concurrently shifted her career goals, based on new, budding interests that she developed, as well as her new majors' emphasis on writing, following her encouraging relationship with an English writing professor. She had an interest in public health, and reproductive rights remain a strong interest, but she felt discouraged about this field from attending a career panel and talking with her aunt, who also helped her decide that dropping pre-med was the right call. Following an inspirational study-abroad experience in South America and internships at the likes of Planned Parenthood clinics, Angela is now completing her fourth and final year of college and applying for nonprofit jobs with an eye toward later graduate studies related to her passion for human rights.

Xiomara struggled through two years as a biochemistry major at her small college, and while her advisor suggested she change her mind following struggles in organic chemistry, especially before she sought tutoring, she tried to retain her goals, noting throughout that she is meant to ensure challenges as part of the experience to reach her future goals. She does not have close friends in the sciences in college, although her friends do help to push her in completing her work. Xiomara does not feel that she pushed herself as hard as she could to excel in her classes. One of the few students who was not economically eligible for an Opportunity Program (the new job her mother secured during her junior year at BELL put the family over the eligibility threshold), Xiomara does wonder, when asked, how things may have been different, and how much more supported she would have felt on campus, had she been able to join such a program. She texted back and forth, frantically, one afternoon during her sophomore year with

her former teacher and mentor, about whether she could still make it in scientific research, as she just did not want to lose her dream of working in the "nano-world."

Her priorities started shifting, however, after she found that she was pregnant the spring of her sophomore year. At first, her goals did not change, as she expressed her trademark attitude, learned from overcoming significant adversity earlier in life, that much of the point and enjoyment in accomplishing something came from that which had to be overcome to get there. She planned to resume her studies at a local four-year college near her family's home a semester after giving birth. Becoming a mother, of course, demanded a lot of her time. Her views of the kind of lifestyle she wanted had shifted, and after struggling through organic chemistry, as well as math and other courses required as a science major, she decided she wanted to pursue what she viewed as an easier and more predictable major and career, in health services administration, in which she hopes to graduate with a Bachelor's degree in 2017.

While I was visiting with Xiomara and her eleven-month-old daughter, in discussing her unexpected switching out of the sciences, in her very matter-of-fact tone, Xiomara remarked, "You know, you can't expect *all* positive outcomes." Even in moving away from the natural sciences, Xiomara was making a scientific remark about the unpredictability and of individuals' trajectories, successes, and challenges over time. Thinking about her decision to change her major to health services administration, she noted that she considers herself "a linear thinker" and someone who is "always a problem-solver," and that she sees her new career goals as more practical and definite than her pursuit of chemistry and nanotechnology.

As Xiomara's comment suggested, one cannot expect to find an exact, infallible formula for success in persisting in STEM in college. Over the course of following students through the end of high school and into and through college, however, a number of key findings started to

emerge with respect to unearthing what seemed to help persisters to persist, sometimes with clear contrast from what kept switchers from doing so. Strong mentoring relationships, impactful extracurricular STEM activities, and the college access approach through which the BELL students passed each helped to shape the landscape of opportunities and experiences that would be open to the students later, in college. As such, each of these three factors, and the components critical to their impact, will be discussed and illustrated with vivid student examples en route to a discussion of students' experiences in college and student progress outcomes in pursuing their STEM career goals to date.

THE POWER OF MENTORING RELATIONSHIPS

Mentoring relationships have been mentioned and to some extent exemplified in some of the ethnographic observations shared to this point. The presence of supportive, mentoring-type relationships with at least one adult were an early theme to emerge in the first phase of this investigation, and in following all of the BELL STEM persisters, as well as the switchers, a more comprehensive portrait of what mattered in mentoring started to appear. Twenty-five of twenty-seven persisters recognized having at least one mentor whom they saw as helping to guide them toward success in their STEM goals in college and beyond, with the mentor (or at least one, in cases where the student recognized two or three) usually being someone with whom the student had a relationship for at least one or two years before college. Seven of the ten switchers who remained at four-year colleges also recognized having such a mentor, although three of these seven reflected back that they did not reach out to utilize their STEM mentor much while in college. Mentors or other sustaining, supportive relationships developed while in college tended to arise with Opportunity Program advisers or directors, and occasionally with professors.

The persisters' descriptions of how mentor figures helped them led to the emergence of five key themes. First, they repeatedly referred to mentors' underlying belief and trust in them and their having a bright future. Related to this, the second feature was that mentors consistently pushed students to "go beyond," challenging and pushing them beyond their expectations and thus expanding the horizons they saw for themselves. Third, part of what seemed to give mentors their influence of helping to sustain student interest and persistence came from their being always available and present to talk with the student in outside of the regular school day and year, during high school and beyond, with these relationships often extending over two, four, or even more years.

Mario's experience with his mentor helps to bring these themes to life. Mario joined his father in the United States from the Dominican Republic at age seventeen and was a very average student his first two years at BELL. His math teacher saw from skills that he sometimes showed in class that he had potential, but as Mario would later recall, he had not been accustomed to showing effort or caring much about his studies. He and his friends back home would rather have fun during class, and he remembers once tearing up a book in front of a teacher there. The trend at BELL among young men with a mediocre C+ average in Junior Institute was all too often to nosedive to barely passing grades, or worse, upon the transition to the tougher Senior Institute classes, but Mario would be the rare student to completely buck this trend.

He could not quite explain it, but instead of his grades dipping 6-10 points as was typical in the move to Senior Institute, Mario's grades rose a full letter grade as he started taking a greater interest in school and seeing it as a means to achieving his goals of becoming an architect. Shortly after his senior year started, Mario decided to join the new college-level

biology course that was being offered through a new dual-enrollment program at BELL, and he quickly formed a strong bond with his teacher. He started staying during lunch after school, talking with her and sometimes doing homework. A strong mutual trust developed, and he would go to his teacher often for advice on various matters, or to talk through a particular situation, and his actions would be shaped in part by feedback she would give him. He wanted to give himself the best opportunities for pursuing his future career, and often she provided constructive criticism, but he enjoyed the attention and advice that he received from her, even when it involved modifying his own behavior to, say, submit more honest assignments or spend more time on his schoolwork outside of class time. Mario went off to one of New York's stronger state colleges focused on engineering and technology careers, with a major in Architectural Technology, and he continues to speak regularly with his mentor for regular check-ins and to consult about important decisions, even while he is also a member of the college's Opportunity Program.

The fourth component that emerged in many relationships was a sense of inspiration that substantively helped shape or refine students' long-term goals. Ramon and Maria's experiences with their mentor, starting in science class and extending after school and through conversations throughout college, exemplify this aspect of mentoring relationships. Finally, the fifth theme that arose from students' discussion of helpful mentoring relationships involved mentors who served as bridge-builders of some sort, helping to connect the students to key resources and programs that would help them in the pursuit of their academic and career goals. Abou zeroed in on this element, alongside most of those discussed above, as central to the close mentoring relationships that helped drive them forward in their STEM pursuits.

Abou was born in New York to a young mother who had recently arrived from Cote D'Ivoire, and he would spend much of his infancy in the daycare center of a public high school designed specifically for teenage mothers. After his parents got divorced, seven-year-old Abou and his younger sister moved with their father back to Cote D'Ivoire, with their mother continuing to live in New York (where she would first attend community college and then graduate from a city college with her Bachelor's degree when Abou was eleven). Young Abou was fascinated by birds as well as superheroes, inspired to one day learn to fly as an airplane pilot. His mother brought Abou and his younger sister back to the Bronx in 2011, and Abou would enroll at BELL shortly before his sixteenth birthday. He had just spent the previous eight-plus years communicating predominantly in his family's native Mandingo, other than when he spoke French, the official language of the schools, during his three to four hours per day at his local public school. (The school also had two or three weeks of unexpected closings per year, on average, due to different protests, some of which were led by students, and some of which turned violent with teachers getting injured.)

Abou's biology teacher at BELL marveled at his ability to pick up his English skills over the two years she taught him after he had barely heard the language for nearly nine years. She was also impressed with his commitment to stay after school to master science material, one of the rare BELL students who made it a goal to ace the state exam (he would eventually score in the low-80s, rarefied air at BELL, especially for a sophomore), and was amused by his stories as the rare young man in the Bronx to proudly walk around wearing cartoon t-shirts and tell an occasional story where he compares himself to a cartoon (like when he is studying hard and says there is steam flying out from his ears). His teacher introduced Abou to me, the school's college access counselor, as she knew he enjoyed spending time talking with students about STEM-

related career goals. She would say that the counselor enjoyed hanging out with Abou and other students with a spark of science interest in his office, like friends, while her own position as a classroom teacher saw her filling more of a second-mother role with the students.

I came to know Abou over his final three years at BELL, working with Abou to try to connect him with weekend and after-school programs that would capitalize on his interest in flying and a potential interest in the related field of aerospace engineering. Abou quickly got involved in a Civic Air Patrol program and weekend enrichment program with science, math, and engineering courses, both in midtown Manhattan, an hour from his Soundview apartment. Abou was quiet and reserved most of the time, but he started showing his more animated side with friends on the soccer field and on special field trips to events like science and engineering festivals. He had written in his application to the weekend enrichment program that he wanted to transfer to a high school in Queens that would allow him to focus more on his career goals, but as time went on he did not seem to explore this option as he had found other ways to explore and expand upon these interests. His junior year, he was hired by a local "science studio" program in the Hunts Point neighborhood adjacent to Soundview, and he enjoyed his work as a paid intern being trained and then teaching hands-on workshops to elementary and middle school students about engineering, design, and invention. He continued to excel in his classes at BELL, although math and the quantitative thinking in the physical sciences were a challenge for him; nonetheless, he remained optimistic and worked with his counselor to apply to college for aerospace and mechanical engineering.

Abou was offered a full-tuition scholarship (plus most of room and board) by the Opportunity Programs at two esteemed engineering schools. He chose the smaller and more personal of the two, where he is now a freshman mechanical engineering major. He found the

transition from BELL to the freshman engineering curriculum (Calculus, Chemistry, and Engineering Studies, among other courses) to be very challenging, but he is sticking it out, feeling supported by his high school mentor as well as his Opportunity Program. He remarks that he expected his classes to become difficult, and that he just needed time to figure out how to adjust to the new levels of rigor; like Xiomara before him, he feels that most things worth doing involve a challenge to get there, and that overcoming hurdles is part and parcel of the journey. Abou returned to BELL, with considerable acclaim (students applauding him, yelling out his name, and sometimes asking him college and career-related questions) during winter break to help lead a local science festival with me.

STEM ENRICHMENT AND OUTREACH PROGRAM EXPERIENCES

Extending student learning beyond the regular core classes offered by BELL was central to my approach, especially in recent years, and the students in the study, especially the persisters, would go on to refer to the impact of these enrichment and outreach-based learning opportunities in deepening and sustaining their interests at various points in their interviews and questionnaire responses. The steady presence of one or more of these supplemental learning opportunities for students in the study, and the ways in which the necessary relationships were forged over time to provide the opportunities, are in many ways unique to BELL. As such, this section describes the evolution of these extra STEM opportunities for BELL students, as well as the core emergent themes of preparation for college success, inspiration, and an overarching lens of exposure to novel experiences involving the accrual of a set of tools, tangible and intangible, that students would recognize as prominent in moving toward their college and career goals.

It became apparent in the early years at BELL that the school did not offer, and was often unable to offer, some of the courses (and expectations to go along with such courses) that would

keep as many doors open as possible for students to pursue a wide range of fields of study in college. I saw this in his time as a founding teacher at the school, and then more fully in working on the college access side with some administrative duties. I felt strongly that there must be ways to help students to be better prepared for college, in engineering or biomedical sciences or other fields, that went beyond what the seeming limitations of what the school could achieve through its core curriculum. The school had been founded in an effort to serve this unique student population's needs in a holistic fashion, and it was recognized early on, even in the founding principal's 106-page planning document, that experiential and workplace learning via internships would be central to this school for older students. Between internships and the bevy of community-based organizations and federally and state-funded programs on college campuses in New York City, I saw as a budding "urban science educator" a number of potential bridges to build to bring additional opportunities and resources to BELL students, especially with the importance of heightened exposure and expectations that had come out of early discussions with the students included in the 1st phase of this study, and had been reinforced by an exciting new research framework for STEM persistence that had been published in *Science* (Graham et al, 2013).

While I see myself as someone who strives to build bridges of opportunity for students, a lot of resistance would be encountered upon reaching out and advocating for BELL students to join or partner with many pre-existing enrichment programs whose mission statements and funding streams ironically emphasized expanding college readiness and access to more economically disadvantaged and traditionally underserved students in urban neighborhoods. Sometimes, it was a long-heralded after-school college readiness program that judged BELL students to be too old or had previously had a negative prior experience with English language

learners, while other times it was a STEM-focused program for underrepresented minority students that worried the students' test scores and experiences at BELL were not up to par with the students to whom they were accustomed.

Sela and her friend, Fati, excelled in one such program along with two other BELL students, taking extra science courses and eye-opening medical career seminars on Saturdays at one of the nation's leading medical school campuses, following advocacy and reassuring the program coordinator that these top BELL students could hold their own even as they were quite different from the Queens, Brooklyn, Manhattan, and suburban Long Island teenagers who formed the rest of the program's participants. Even after their experience, when one of Fati's close friends applied the following year, BELL's Class of 2015 was turned down because her math and science test scores were not quite in the 80s following her 10th grade year, her first in the US. (For Fati and some of her peers – especially some of her fellow West African students – who quickly rose to the top of their BELL classes and found themselves bored or frustrated in some of their classes, enrichment opportunities and the mentoring relationships went with them were leveraged to keep these students from leaving BELL for a GED program.)

A summer scientific research program that Mamady, Deepak, and three other BELL students completed at another leading medical center, with which BELL had started to build a relationship, expressed some valid concerns and recommendations as to how to better prepare BELL students for their program (which often served students from private and selective public high schools), but also questioned Mamady's readiness for college in a manner that seemed to reflect a lack of understanding of how urban science students manifest their interests and strengths. Cultural relevance and congruity should not be taken for granted in learning experiences *outside* of the classroom either, but it was difficult to explain this in a tangible, spur-

of-the-moment fashion to the two high-level physicians and scientists who really did want to help.

Sela and some of BELL's other particularly resilient students had a habit of channeling the doubts and negativity of others as added motivation, and this approach spread to me, using outside slights to add fuel to the fight to expand the learning opportunities available to BELL students. On the other hand, being looked at in a negative light, constantly from a deficit perspective, was nothing new to BELL, however, especially following the 2012 College Now debacle. Providing avenues toward providing advanced and college-level courses had long been an interest among certain BELL staff members, and the school had a relationship with the College Now dual-enrollment program office at a local community college where relatively strong students could take free advanced and college-credit courses after school or during the summer. That particular college did not offer much in the way of advanced science, technology, or engineering-related courses that some students were curious to try, however, and was starting to place far greater restrictions on who could take the courses that were offered on the basis of Regents exam scores, part of the city college system's push toward increased rigor and accountability.

For the 2011-12 school year, I had reached out to another local community college and was able to arrange for interested students to take college-credit engineering design and computer programming courses, filling a hole as BELL did not have any other opportunities (i.e. any courses or internship placements) through which its many students who were curious about engineering or computer-related fields could learn more and make themselves more attractive candidates to colleges in these fields. Then, during a college visit with seniors one afternoon to one of the city university system's most highly-reputed colleges, after I was reprimanded by the

college's admissions office for bringing this group of students rather than small groups with parents present (a requirement stated nowhere on the group visit reservation website and which clearly displayed a bias toward students whose parents could come with them to the campus, and presumably understand the *lingua franca* there), he and the students had a chance meeting with the college's College Now director. The director, an African American man from the Bronx, was passionate about seeing more young people from his borough, and young men of color, in particular, on his campus as College Now students and eventually as college students. He visited BELL and invited groups of BELL students to campus for special events, and twelve BELL students enrolled in writing, communications, and psychology courses, nearly all of whom would to earn a B or higher but none of whom were even close to admissibility to the college due chiefly to their SAT scores.

The BELL students and staff were still grateful for the opportunity, but soon the director found himself in trouble with senior administration for his work with BELL, and BELL was instructed not to send students to this college for courses in the future. The main claims made by a senior administrator of a system that proclaims itself to be the nation's leading urban public university system were that BELL already had its one dual-enrollment program partner and that its students in the Bronx would be better off staying in their borough rather than crossing into lower Manhattan to take courses at one of the jewels of the university system. Other schools with longer-standing reputations and higher test scores had multiple College Now program partners, even across borough borders, but this did not seem particularly relevant to those in power, nor did the students' feedback that they felt they had gained a great deal in rigor and content that was unavailable in the courses at BELL's primary partner. In the years that followed, BELL's Bronx partner would continue to become stricter about who could take which

courses, including the math courses that were a clear gateway into various STEM majors, even discouraging two students who had placed into a Calculus course (following a semester-long lunchtime independent study with a math teacher, as BELL did not offer pre-calculus) based on the college's own placement exam.

Forging Partnerships and Advancing Learning Opportunities

A couple of lessons were crystallized from this array of experiences that would shape supplemental STEM opportunities moving forward at BELL, which would heretofore take on the emancipatory tone that would lead to the evolution of this very research study. The first key lesson was that BELL would need to implement advanced and college-credit course offerings, generate momentum among faculty and staff to bring them to fruition, and solve the logistics of fitting them into a school with a set approach to heterogeneous classrooms and funding that was already stretched thin. Second, it started to become evident that just as achieving rigorous instruction and pushing students beyond their expectations in the classroom was rooted in relationships with students, so too would any successful enrichment and outreach program involvement require the formation of key relationships with outside organizations, as well as with administrative, teacher, and student constituents within the school.

Connecting Students to Laboratory Research Opportunities

Summer research internships, mostly through American Chemical Society Project SEED, were the experience most frequently cited by STEM persisters as important and impactful in spurring them onward toward success in STEM in college. Some students enjoyed the experience from the start, while others found its utility expanded once they were in college, but overall those who participated in these paid science lab research programs praised the hands-on experience and exposure to the tools and knowledge they would need in college and in a life

spent working in science, medicine, or engineering. As would often be the case with the most impactful programs, the trajectory toward building and sustaining New York City's largest Project SEED program of the early to mid-2010s started with cold-calling and relationship-building. I had heard about Project SEED in passing when I had cold-called chemistry professors about laboratory positions when he was a high school student in 2003 (he was ineligible), but the program did not come to BELL until after an unassuming email exchange with ACS Project SEED headquarters in Washington, DC during the 2009-10 school year. The goal was just to place a student or two in a lab that summer, but the response, which included the phone numbers of two longtime SEED coordinators from New Jersey, would lead to grander outcomes than he or the BELL students could have imagined.

I was able to reach one of these women, who helped place two BELL students in 2010 and suggested I become a Project SEED coordinator in the Bronx for subsequent summers, offering to guide me through the process. She was a longtime SEED guru, a retired Eastman Kodak chemist who had been volunteering as a SEED coordinator for twenty-five years, placing hundreds of motivated, low-income high school students in research labs, arranging the details with scientist colleagues of hers across New Jersey and New York and securing stipends for the students, often reaching deep into her own pockets to meet gaps unmet by the laboratories themselves, the American Chemical Society, and other funding sources. Sara welcomed the idea of a young new SEED coordinator and became a guide and mentor figure to me, providing encouragement and advice as a friend of the BELL community who believed deeply in the power of early exposure to research, and who also saw the importance of linking Project SEED to solid college and career advising.

I would even find myself sitting at an IHOP in New Jersey one Sunday soaking up decades of science enrichment and outreach wisdom while Sara and her longtime fellow SEED coordinator and friend, Natalie, ate pancakes together. Natalie was a longtime chemistry teacher in an urban public high school in New Jersey, and a former national science teacher of the year, and I learned a great deal about sustained belief in students and goodwill of educators and scientists from listening to these two women, four and five decades my senior, and a bit amazed that they had included me on one of their regular pancake brunch meetings. I would recruit various scientists from across New York-area universities (mostly through cold-calling, occasionally with a personal connection such as the MD/PhD student who acted as Aissatou's epilepsy research mentor, who was my roommate), which could be a daunting task at times alongside ensuring funding for the students' stipends, but having a veteran like Sara a phone call away made the task seem more reasonable from the beginning. Students' experiences as SEED scholars working in world-class facilities and reviewing their research reports at the end of the summer made it all worth it, as did some of the feedback that students provided about their experience, some of whom have been introduced above.

Another example was Veronica, now a junior biology major, who spent the summer before her senior year in a biochemistry lab at NYU, which she would later describe as one of the highlights of her entire educational career and "one of the best things ever." While the main allure for her had been the excitement of coming to downtown Manhattan everyday while she was in SEED, the perspective of a being a college student (and one who has done better in her science courses than her general education courses) is such that she now recognizes that the skills and ideas that her lab mentor was teaching her were great preparation for the work she would be doing in college. Then there was Jhoan, who after spending some time getting to know

his counselor and being selected for summer research in chemical engineering – which he would ultimately find to be an inspiration and motivating factor, along with college visits seeing engineering facilities and meeting engineering majors, for going to college and pursuing an engineering career – initially broke down and asked why he was receiving all of this special attention. He had been raised between his mother in a housing project in Harlem and his grandparents back in the Dominican Republic, and had been classified as a special-needs student in elementary school in New York, and he did not quite know how to make sense of all the support and opportunities being offered to him by his two counselors at BELL. Jhoan laments that his younger brothers did not follow his example of believing in the power of schooling to meet their goals, and has faced a tumultuous college career himself in a setting that has not been the most supportive, but he is a junior mechanical engineering technology major and National Guard technician-in-training who has plans of one day earning a Master's degree as well.

Funding and Establishing a Biomedical Sciences Program

Funding was one of my primary concerns during each year's SEED application cycle (along with establishing relationships with university faculty who would be strong and supportive mentors for the BELL students); however, what seemed at first like chance encounters with college readiness grants would become central to launching and sustaining paid summer research internships as well as new partnerships and advanced coursework that would forge the likes of a fledgling biomedical sciences pipeline program within the school. One day when I was still a full-time classroom science teacher, BELL's administration congratulated me on a new role as administrator for a state-funded college access grant that BELL had been awarded with the help of one of its former instructional coaches from a non-profit with a holistic urban school change focus that had been a supporter of BELL since its founding. I had no idea

how to respond, or what any of this meant, or if the congratulations were some sort of a joke, but after speaking with the principal, the potential courses of action became a bit clearer. The BELL administration was given a lot of discretion over how exactly to spend the money, as long as it went toward activities, trips, and programs that contributed to improving students' college readiness and motivation to go to college. Over the course of the next several months, a great deal of learning took place around the nitty-gritty details of administering and managing a grant, planning a college trip that sought to address students' needs and interests (and then realizing a need to go back to the drawing board for the following year), and how to negotiate matters like permitting a few thousand dollars to go toward students' summer research stipends for what turned out to be an overly ambitious first summer as a SEED coordinator.

This experience would be helpful a couple years later when BELL's principal received word from the leadership of the aforementioned nonprofit of a local foundation that was looking to fund innovating capacity-building programs in a few high-needs urban high schools. I had been exploring Project Lead the Way (PLTW), recognized as the nation's up-and-coming leading supplemental STEM curriculum developer ("Project Lead the Way," 2016), as well as partnerships with universities that would train school staff as adjunct instructors to teach college-credit courses on site at their schools, after befriending an engineering admissions recruiter from a large upstate university while attending a statewide college advising and admissions conference. I discussed these programs with the principal, wrote a brief proposal in response to the foundation's questions, and the foundation saw great promise in BELL's potential to take advanced learning opportunities into its own hands and funded both programs for what would become three years (and running).

PLTW had an industry-vetted set of pre-engineering courses and a new biomedical sciences program, both reflective of high-demand career fields that drew the interest of a number of BELL students. The principal decided to opt for the biomedical sciences route, largely in a nod to the alignment of biomedical and health professions' broader social and communal aims with the school's preference toward in and out-of-school experiences that involved strengthening and giving back to the community. While still not having any true laboratory spaces, BELL was now able to outfit a regular classroom with all of the materials and equipment necessary for an innovative, hands-on PLTW Principles of Biomedical Sciences course, in which students would be confronted with a crime scene and spend the year exploring a variety of different forensic, diagnostic, and other analytical techniques, in the greater context of understanding body systems and diseases, en route to solving the mystery. The Biomedical Sciences course launched for the 2013-14 school year, the first that any New York City school joined PLTW's Biomedical Sciences curriculum pathway program.

A BELL biology teacher was recruited to teach the course, attending an extensive summer training with other teachers from across the mid-Atlantic states and frustratingly finding some who expressed skepticism about her unique school's success as a PLTW partner as she described BELL to them. This teacher had already been key to helping students to form positive associations with science classes and teachers in their time in the Junior Institute and had already been in the habit of introducing interested students, such as Abou, to the counselor/researcher for science career/college advice and internship searches; her role in this regard would only expand as she became the welcoming "gateway" instructor in BELL's young new biomedical sciences pipeline. The course was advertised and meetings were held to recruit students for the course, and a core group of over fifteen students with interests in medicine or other sciences – and/or

who enjoyed taking classes with this biology teacher – participated in the course, which met after school for 4.5 hours per week (shifting toward more during-school time future years).

The dual-enrollment college courses were not able to start that year due to scheduling, logistics, and student and staff capacity concerns, but College Biology and College Public Affairs courses were rolled out the following year in partnership with a university upstate. The Biology course, taught by the new BELL science faculty member who would quickly become a mentor to Mario and other students, served as a continuation of sorts for dedicated students from the PLTW Principles of Biomedical Sciences course. The school has not been able to expand its PLTW and dual-enrollment college program courses to the extent that was originally planned; nonetheless, the sequence of the PLTW intro course and the College Biology course, supplemented by special trips to laboratories, hospitals, the USA Science and Engineering Festival, and an optional Health Professions Club, formed a rudimentary Biomedical Sciences pipeline program and learning community cohort of like-minded, highly-motivated students who enjoyed learning science and could push further than in their regular classes. At the same time, these courses retained the supports characteristic of the BELL environment, unlike some outside College Now courses (which admittedly can allow students to grow in other, more independent ways). I remained in touch with the executive director of the foundation whose funding allowed us to implement these programs, checking in about how they were progressing throughout the initial two years of funding. At the culmination of the two-year pilot, she came to observe the courses, and a focus group of students who had participated in PLTW as well as the dual-enrollment College Biology course was arranged. One after another, the students, most of whom were about to graduate and go off to college, spoke up to discuss the benefits that they felt came from these new learning opportunities at BELL. Their feedback ranged from feeling more

prepared for college to having a space and time at BELL to be around the positive peer pressure of other focused students with similar goals, to becoming better science students and to having a better understanding of what would lie ahead in their futures.

Arianny and Juana provide two striking examples of the impact of this two-year sequence. Juana joined her mother in the Bronx following her arrival from Santo Domingo, Dominican Republic in 2011, quickly showing herself to be a relatively strong student within the context of BELL, an outspoken hard rock fan who enjoyed playing the guitar and talked about wanting to be a dentist even though she did not find science all that interesting. Her biology teacher, who would become her PLTW instructor, had connected her with the counselor/researcher. She was shocked and initially dismayed to learn from him of the many years that it took to become a dentist or physician in the US, as she was accustomed to a system in her native DR, like many other nations, where an undergraduate degree was sufficient. Nonetheless, she remained interested because she found the dentistry and working with people's teeth to be so fascinating, and she would continue talking with her counselor about what she could be doing while at BELL so that she could be on the right track to become a dentist. PLTW and the College Biology course were part of this formula, and through her engaging experience in PLTW she would exclaim one day, "Remember how I said I didn't like science. Now I'm eating my words, it's so cool!"

Juana decided she wanted to go beyond these experiences as well, getting a better sense for the pathway from pre-dental/medical biology (or other) major through dental/medical school than could be achieved by just talking and looking online or in books, and she also wanted to provide a space and opportunity for other students to learn about how to pursue these professions in the United States. This prompted the counselor to reach out to a state-funded organization that

strives to help individuals in underserved communities to enter the health professions and return to serve their communities in their professional capacities. Juana, the counselor, and the organization's program coordinator and director were able to agree on launching a Health Professions club, including speakers and visits to different sites throughout New York City, for Juana's senior year, concurrent with the College Biology course that she and her friends and classmates were taking. (Unfortunately, due to funding constraints and other issues, curiously including BELL students' math Regents scores at the end of 10th grade, that organization has not been able to continue to partner with BELL to provide similar opportunities this year.) Juana also enjoyed being part of a new budding relationship that BELL started forming during her senior year as a new partner school of the Young Women in Biology (YWIB) program. Part of her interest in health care careers stemmed from her extensive experience being treated for a bevy of allergies as a girl in the DR, so her eyes opened wide when she met a young female biologist and biotech entrepreneur who was developing an allergy medication toothpaste. This charismatic scientist then visited the school for BELL's latest incarnation of a "Meet the Scientist" series to speak with Juana as well as any of her friends and classmates who wanted to attend.

Arianny had arrived from Santiago, Dominican Republic in 2010, and while she entered with no understanding of English and limited exposure to even middle school math and science content, she did well in her BELL classes and progressed steadily through working hard every day, receiving help from supportive teachers when she needed it, and a large dose of positivity and optimism. Arianny dreamed of being a physical therapist and seemed to find ways to channel adversity into motivation to pursue this goal. She was open in pointing out that some of her classmates at BELL, including Juana, had come from more of a middle-class background in

the Dominican Republic (which is reflective of different educational and economic backgrounds in that country, from my time there and conversations with students, than what American academics and educators tend to consider within the scope of class structure of this country). Juana's family in the DR had considerably more resources at hand than her own family, and part of Arianny's identity seemed to include an underlying sense of pride as a striver both in the DR and here in the Bronx. Economic challenges back home were nothing, however, compared to how heartbroken she felt when her older brother was sentenced to thirty years in prison for a murder conviction that she and her family felt to be totally erroneous. Effectively losing her brother, and having her father move to America, was not easy for Arianny as she entered adolescence, and then she would have a major accident while riding on a *motoconcho*. Ultimately, this particular experience and learning to regain full motion of her leg fascinated Arianny with the body and introduced her to the exciting field of physical therapy.

Fast-forwarding back to her time at BELL, she joined the inaugural PLTW course, which opened her eyes further to the wonders of the life sciences, and then continued to excel in the College Biology course as well. Humbly and quietly (she was quite shy by nature), she consistently earned higher grades in most of her classes than most students who had similar or stronger prior schooling experiences and skills. She continued to build her interests, skills, and self-confidence by becoming a peer health counselor for the school community, starting by spending the summer before her senior year immersed in a series of clinical rotations at a local hospital and in discussions of young adult health issues with the other aspiring health care leaders.

New York Presbyterian Hospital had opened a full-service school-based health clinic inside the building where BELL is located, a major improvement from the prior arrangement of

one part-time nurse to serve all of the health needs of students from six schools. I had started speaking with the clinic's health educator and started advocating for some type of internship program in conjunction with the world-class system that is New York Presbyterian. I approached the health educator in light of his knowledge of another major hospital system with clinics in nearby schools forming relationships with those schools that led to special clinical internships and other enrichment opportunities. We remained in contact, and a year later, the health educator was able to coordinate with the hospital system to launch a peer health educator program in which a council of students from schools within the building, following a pilot involving two BELL students, would rotate through different hospital departments over the summer and spend time at least weekly during the summer and school year in discussions and trainings related to young adult and overall community health issues, as well as leading workshops about these topics in the schools and local community.

Arianny's test scores, namely an SAT composite of 580 and English Regents of 65, were quite low even within the context of the students in this study, but with the strength of nearly all of her grades, evidence of her clear resilience of the manner in which she kept challenging herself, and relationships that BELL had forged over the years, Arianny was admitted with full-tuition Opportunity Program scholarships to two four-year colleges upstate. Juana, who had become one of her best friends, was admitted to the same two colleges with similar offers, and the two are now roommates. Juana is a pre-dental Biology major, and Arianny is a pre-Physical Therapy Health Sciences major who earned a 3.6 during her first semester of college.

Partnerships to Support College Access and Open Paths to Engineering

With a biomedical sciences pipeline program established at BELL, I was bothered that there remained virtually no course options available for the sizable number of students,

especially males, who expressed an interest in the more applied sciences, namely engineering and computer science/information technology. (The earlier College Now courses in these areas, at a non-BELL partner school, were no longer consistently offered due to the college's claim of a lack of student interest.) Around the same time that BELL launched its PLTW course, a local community center contacted me. One of the center's staff members had met me at a college access professional development training that we had both attended, and the center was interested in forming relationships with local school(s) to build stronger college-going cultures and college readiness programs together. Initial conversations would turn into state and foundation grant-funded collaboration between the two organizations. This included starting, in 2014, a new weekly introductory computer programming, technology, and engineering program, which is now expanding to include robotics. The partnership also included a college preparatory summer program that would evolve to include a novel skill-building SAT prep course focused on the needs of BELL's ELL population (as even top students had felt alienated in free local courses offered for the general population), as well as a program in which cadres of three current BELL students become paid peer college access counselors, an extension of peer leadership opportunities from long-standing peer tutoring and co-teaching opportunities that even features an office run for and by students.

Ignacio was not one of the peer counselors, but he spent a lot of time in the office during lunch and after school, helping to expose other Dominican young men who were his friends to key people and resources, and of course playing video games with them and discussing what they were learning in their Wednesday technology program. Ignacio had spent his early childhood in the US, then grew up for ten years in Santo Domingo before his family returned to the Bronx. He was the extremely rare BELL student to have attended an esteemed private school

in the Dominican Republic that seemed to keep students' skills at or close to American grade level – one of about four BELL's Dominican majority, in its history, to have attended such a school – while working at his parents' fried chicken restaurant. A major accident and the restaurant's closing led the family to return to the Bronx, where Ignacio had enrolled at BELL with a passion for video games and an interest in engineering and computers, but a number of failing math grades from his prior school.

Perhaps unsurprisingly, Ignacio was immediately one of BELL's strongest students and cast in the role of peer tutor to help students who were struggling to grasp the basics of algebra. This was a new role for him, but there was also a risk of disengagement that had been observed before with the rare case of students who had entered the school near grade level in their skills and with at least some command of the English language. Ignacio developed a relationship with his counselor, who would discuss his unique educational transition with him and encourage him to find ways to challenge himself – especially with the knowledge that no BELL student had ever been admitted directly into a true four-year engineering program (only engineering technology programs, and even this was rare) in large part due to test scores and limited course offerings – but he was itching to pursue his interest in computers and technology. He was thus elated to be part of BELL's first computer programming and engineering internship program with the community center, where he learned basic programming, saw the relevance of mathematics and logical thinking to his career goals, built his confidence and self-efficacy in solidifying a goal of becoming a computer engineering, and above all found a mentor in the young Latino college access director from the center who was leading the program. At my urging (as counselor with data specialist and school-scheduling roles), BELL also offered a pre-calculus course for the first time for Ignacio's senior year; it ended up being in name only, with the course exploring only a

small portion of a standard Algebra II course. Ignacio and other students who had answered more than half of the Algebra I Regents exam questions correctly (which meant a "79" or higher on the generously scaled exam) were enrolled in the course, which the counselor knew would be crucial to having a fighting chance at even a special admissions route (i.e. Opportunity Program admissions) to engineering school.

After a total of zero engineering acceptances for the first three classes combined, Ignacio was one of four BELL students that year to be accepted to a Bachelor's program in engineering. Three of the four, including Ignacio and his friend, Rahman, also from the engineering internship, were among ten total New York City students offered a full Opportunity Program scholarship, valued at over $230,000, at one of the region's more highly acclaimed engineering-focused universities. Rahman and Ignacio just began their second semester as computer engineering majors. The third student, Tamana, who became BELL's first female Bangladeshi student to graduate (others have gotten married or left school for other reasons) following internships with a major civil engineering firm and in a research lab at NYU, and visits to Columbia engineering labs (through BELL's new partnership with Columbia's Engineering Outreach office) is in her second semester as a civil engineering major who credits close mentoring alongside these new experiences venturing outside her comfort zone as instrumental to her pursuits.

PARTNERSHIPS WITH COLLEGES

While mentoring relationships and partnerships that led to STEM enrichment and outreach programs were important components of students' pathways toward college, any comprehensive discussion of the moving parts that were involved in these students' pathway into and through college must make mention of the particular approach to college access work that

was employed, and has been alluded to above. As a former scientist, I took what I refer to as a largely targeted, data-driven approach from the beginning of BELL's college access advising, before its first class had graduated. I had started learning about the doors that could be opened by Opportunity Programs and their very specific admissions windows and started collecting data about regular admission and Opportunity Program admissions guidelines and finding potential best-fit schools for a variety of BELL students. It became apparent that students with at least a low-B average who had at least passed most, if not all, of their Regents exams before senior year could have at least some four-year college options with significant financial aid. The statewide college access and admissions community would point out at conferences and state advocacy day that demand of economically OP-eligible students exceeds the supply of all seats available across the seat by a factor of 10, but this served more as a motivator to find ways to improve a given student's chance from 10% than a deterrent of the seemingly slim chances.

A spreadsheet was prepared and tweaked over the years of all public and private colleges in the state that offered an Opportunity Program, including data related to regular and OP admissions criteria (focusing on GPA, Regents, SAT scores, and strength of schedule, as well as whether the school was SAT-optional for some or all applicants), graduation rates (four and six-year and disaggregated by racial/ethnic group), measures of racial and socioeconomic diversity, approximate expected loan burden for low-income students, and popular majors, among other information. It seemed ironic that the local public colleges tended to have graduation rates significantly lower but minimum SAT scores that were higher than other public and private universities with similar reputations and profiles, but at the same time, this was further motivation to figure out how to get students accepted, and with large scholarship packages, at schools outside of that system, which had long been a desire of BELL's founding principal.

Targeted College Visits: "Crazy College Tours"

To better understand what colleges were looking for and start building key contacts, the counselor met representatives at college fairs and conferences, invited representatives to school to speak with students, and planned targeted, multi-site college trips that a current peer college counselor prefers calling the "Crazy College Tour" series. Two busloads of BELL juniors and seniors would traverse wide swaths of New York state (plus a subway carful or so traversing New York City) over a two-day period, with each student visiting two colleges out of the twelve to fourteen being visited in total, as carefully "targeted" or assigned based on career goals and academic performance. Diverse sets of colleges, across the spectrum of selectivity and academic foci, were selected and contacted to represent BELL students' skills and interests.

The purpose of the trips was twofold: (a) to inspire and open BELL students' eyes to what their worlds could look like in the near future by having them planted at universities that could be a good fit for them and (b) to builder closer connections with universities by putting them in direct contact with BELL students, where the students can demonstrate their maturity and interest. Some of the more regularly visited universities came to be those with which BELL had built a relationship and which would personalize the visits to include such components as multicultural student panels or lunches, visits to classes of interest to students, tours of special laboratories or other facilities related to students' interests, and meetings with Opportunity Program staff. (As an extension of explicit STEM outreach and enrichment activities, a number of students would mention their experiences meeting current STEM majors or seeing facilities where students engaged in high-interest, STEM career-related projects, or the individualized college counseling process and conversations with a focus on their STEM career interests, as experiences that contributed to their understanding of and persistence in their major in college.)

The actual application process involved extensive support through each step from building an optimal college list to walking through the applications step-by-step, from completing financial aid applications and supplemental verification forms, from extra Opportunity Program and scholarship forms, essays, and interviews through making informed college decisions and completing all necessary documentation and college account materials for enrolling and actually starting classes. In terms of building college lists, members of BELL's first graduating class served as "guinea pigs" of sorts employing what might be thought of as a targeted "shotgun" approach aimed at solving a complex optimization problem. A unique feature of this process at BELL in each senior class through the present, reflecting a combination of the nature of the school community and where students and their families are in their awareness of higher education opportunities, is the extent to which students "buy in" to applying more or less exclusively to personally crafted lists of schools that are co-constructed with, but initiated by, the counselor (rather than the student).

Maximizing Students' Options for College Success

I view the challenge of where students go to college to be an applied version of a multivariate optimization problem. In order to provide students with the best possible chances of success through college graduation, one must maximize the level of financial support that a student would be likely to receive (with the full cost of attendance – tuition, room, and board – being the ideal), the relative academic performance of the institution (higher graduation rates overall, and for underrepresented students in particular, are the ideal, with reputation entering into the equation as well), and the academic and psychosocial supports, and cultural congruence and sense of community, that the student is likely to encounter (based on the counselor's knowledge of and familiarity with key contacts within the campus community and general sense

of campus climate). People and institutional behavior with respect to these variables are too complex and inexact to boil down to the one or two institutions that would reside in a region of a relative maximum for each variable for each given student's profile, but the counselor's conceptual approach is analogous to solving such a problem.

Not surprisingly, limits in publically available data kept me from being able to understand students' admissions and financial aid chances as well as likely levels of supports at many institutions, especially for the majority of students whose SAT scores were in the relatively uncharted waters (for heavily focusing on four-year college admissions) of the 300s in math and reading. Standard practice across other schools in BELL's network continues to be focusing on local community college options for such students, in which the students will often face another war of attrition in the form of sequences of required remedial courses before pursuing their major or, at best, a support program that will set them on the path toward likely completion of an Associate's within three years. An exception, as observed from speaking with students from the U-State comparison group and with counselors from partner schools, arises when students from such schools self-select into working with an outside college access organization that helps guide them into and through college, with a focus on public universities throughout the state.

The counselor tried to balance the available data with a strong sense of optimism and idealism in constructing college lists and continuing through the application process with the first cohort, but it became quite apparent over time that the vast majority of universities would be adhering strictly to their test score expectations, especially when considering students for very generous Opportunity Program packages and students from a new, unknown, high-poverty, high-needs school such as BELL. Some institutions were thrown off by the seeming mismatch between student grades and Regents and SAT scores and the lack of AP and Honors courses,

while many did not know what to do with students who were older than typical high school graduates and had only been learning English for three or four years. (BELL tried having a few of its top students take the TOEFL, but without the kind of extensive training that professional-class international students tend to receive in practicing for it, their scores were quite uncompetitive.)

A number of institutions that had been open in their desire to diversify by attracting English language learners and/or low-income students from urban centers made it clear to the counselor, and to students in their repeated rejection letters, that they were viewed as high-risk students, not the kind of diversity that that university expected to immediately pay dividends. Some universities were quite candid with the counselor in these matters, and with such institutions, advocating with early evidence for the students' resilience and potential for success did not seem to be reaping any benefits. The recurring doubts were similar to those observed with many of the enrichment programs, and in some ways it seemed like a cycle of futility. Exclusion from enrichment programs kept students from building some of the proficiencies that colleges were looking for, and then colleges' later rejections had the potential to threaten BELL students', and the school's, sense of what was truly possible for them. Through these frustrations, however, close working relationships started to emerge with the very few universities that at least took the time to interview and consider even a few BELL students, generally mid-level four-year institutions that preferred factors other than SAT scores and were willing to spend time coming to a better understanding of the students and school context. As had been the case in the classroom and with outreach and enrichment activities, demonstrating deep belief in the students (in this case in the form of advocacy and interpretation of the fabric of the student body and school to the outside) with a deep-seated understanding of context, allowed

for the development of relationships that would seem to open veritable doors of new opportunities where others had been slammed shut.

U-State: Building a High School – College Partnership and Pipeline

U-State is a striking example of the kinds of relationships that can be built to open new opportunities for students, and arguably to alter a school community's very conception of college access and success, while also proving to be beneficial to the university. The small state college decided in 2009 to become SAT-optional, one of the very first public four-year universities in the northeast to do so. The college's admissions office and senior administration had opted to go against the grain of the state's public universities making admissions decisions based mostly (or exclusively, in many cases) on the basis of test scores (SAT and Regents) and high school GPA. Their institutional research suggested that understanding the greater context of each students' high school performance, from consideration of essays and recommendation letters to GPA, Regents scores, and strength of schedule relative to what was available in the school and optional interviews, would be more helpful than the old method.

U-State wanted to construct its freshman classes with the kind of personalization that it strived for once students arrived on campus, and it also wanted to build a more diverse student body to better reflect the state's young people, which was a challenge with its isolated location in a mostly white, rural area. The counselor/researcher had seen U-State on a test-optional list and also recalled a passage about the remote little state school in the back of the *Revitalizing Undergraduate Science* text that he had found in the Brandeis Chemistry garbage bin. In that excerpt, the author had written about how the college's math department and its personal, holistic approach had become one of the nation's largest producers of mathematics majors by the mid-1980s, quite a feat for a comprehensive former teacher's college that was four to nine times

smaller than large public flagship institutions and which barely had a math department just twenty-five years earlier.

I met "D," U-State's local admissions counselor at a college fair in 2011, just before BELL's first senior class started applying to college, introducing himself and BELL and asking about student support in math and science based on what he had read about the math department's prior work. D then came to speak at BELL and captivated a group of seniors with an emotional, motivating discussion about college in general and U-State in particular. Several members of BELL's senior class, including nearly all of the "A" and "B" students with total SAT scores well under 800, applied to U-State, sight unseen. During the spring 2012 semester, the college's Opportunity Program coordinator interviewed a number of these students, and the counselor/researcher visited campus shortly thereafter for a counselors' conference showcasing the remote region's four universities. D and his colleagues had invited various counselors from across the state, including five NYC-area counselors who had confirmed their attendance, but following a thirteen-hour trip with a three-hour stalling en route, the BELL counselor seemed to be the only person in attendance from anywhere south of Albany.

The feel at U-State, which acted as the lead institution of the conference, was markedly more friendly and personal than seemed customary on other public or private college campuses, starting with the counselor's very first interactions there. He knew to bring food with him based on a well-intentioned email prior to the conference asking if bacon would be suitable to his kosher dietary restrictions, and upon arriving late and being driven by an Assistant Admissions Director from the town's bus stop to the conference's opening presentation, he scurried to eat a few fruits and vegetables from the salad bar as the speaker was making some final comments. As the counselor/researcher went to throw away his garbage in a rush to follow the group to their

next session, the man who had made the opening remarks interjected and took his plate, “Relax, I’ve got this. Welcome to U-State. Don’t worry about this. Just go ahead and follow the group.” This man, Steve, happened to be the college’s Director of Admissions, and one of the main driving forces behind U-State’s transition to a more holistic admissions process. In addition to meeting individuals from the other universities over the next twenty-four hours, including the Opportunity Program directors from the private liberal arts college and engineering-focused research university nearby, D arranged for him to meet with Ajit, U-State’s OP director.

Ajit and his team had recently interviewed BELL students and over a hundred others, a requirement almost unheard-of throughout the state’s public university systems, as part of deciding which thirty-five to accept and support as OP students. He sat the counselor down in his office, which was next to a student work and lounging area, in front of a white board where he had jotted some notes about first-year seminars and first-year interest group clusters, in which groups of students with similar interests and/or needs would take a group of classes together as part of a cohort model of student support. Ajit’s conversation with the counselor switched back and forth between trying to better understand the BELL students and an open-brainstorm asking for advice as to how to best structure his first-year programs to best support the BELL students who he was thinking of admitting. Such candid, reflective conversations had never been opened up to me before, but it was clear that there was a strong interest to make something work, with Ajit and his colleagues making note of the state’s increasing English language learner population and their consequent feeling that they should find ways to start serving this population. He would later reflect that BELL was the first school with such a population to demonstrate such

interest, so it made sense to start by consulting with BELL, first with me and then with the twelfth grade English teacher as well in combination with U-State's writing center director.

D, Steve, Ajit, and the counselor/researcher would remain in close contact throughout the years that followed, including D's transition to the prestigious engineering-dominated university down the road, which is not coincidentally the same school where three BELL alumni are in their second semester as computer or civil engineering majors. U-State has welcomed groups of BELL students for personalized visits on campus on three occasions, including a unique custom that has developed upon the BELL students' arrival in the region. Ajit drives a van of his OP students, including some of his BELL alumni, over half an hour to have dinner with the BELL group at the Burger King next to the economy motel where the BELL group stays the night before sub-groups visit U-State and the neighboring colleges.

At present, there are seventeen BELL alumni studying at U-State, more than at any other postsecondary institution. Ajit has acknowledged that he was not sure what was going to happen when he brought in the first three students to his program, but as he and his colleagues have worked with more BELL alumni over time, they would come to recognize BELL students as a "best-kept secret," as they have remained seemingly invisible even to most of U-State's peer institutions (i.e. those with similar selectivity and performance profiles). Six of the BELL STEM persisters and four of the switchers are current U-State students in good standing; another STEM persister started her college career there (and misses the support and inspiration she drew from her U-State experience) before transferring to another four-year college to be closer to her mother following her more recent immigration to the US, and one of the switchers who left the four-year pipeline started there before becoming pregnant. While most of the U-State comparison group students in the study resembled some of BELL's strongest STEM persisters

on the basis of high school characteristics, the students that BELL has sent on to U-State generally had lower test scores, with U-State generally being the only four-year institution that accepted them. A notable exception to this pattern, but simultaneously a testament to the power of building relationships with colleges, lies in the path that Sela has taken since her senior year at BELL.

BELL's 2014 valedictorian, Sela was rejected from all seven of the institutions that she and her counselor had carefully selected, a set of highly selective institutions with deep pockets that pledged to meet full financial need of all admitted students, predominantly with grants and scholarships, and that boasted holistic admissions processes including test-optional policies. Sela's father's job as a locksmith placed her outside of OP eligibility. Her grades and the extent to which she had challenged herself in and outside of the classroom were undeniable (from the A- in Calculus I on Saturdays in Brooklyn – she once started crying out of frustration when her BELL classmates just stared at her quizzically when she stood up to explain the math she was learning as part of a portfolio presentation in which many of them were learning to master solving two-step linear equations – to producing BELL's first yearbook and working at a hospital in the summer), but a composite SAT score of 850 was not taking her anywhere as a regular-admissions candidate, let alone one in need of generous scholarship funding. An outside observer could argue that Sela should have had a couple "safety schools" on her list, but Sela was clear that she was not bound for community college while the peers she had tutored would go on to four-year schools, and the four-year schools that would consider her would not be expected to provide a generous aid package, making matriculation impossible. Sela was always humble, but now she and her self-confidence seemed crushed.

After speaking with Sela, the counselor reached out to D and then to Steve about what U-State and its Honors Program might be able to do in the eleventh hour. Steve was accustomed to D's strong advocacy for BELL students, and he had come to believe in the hard-working, determined young people he had met from the school. Within a few weeks, shortly before she delivered her valedictory address, Sela was admitted to U-State and its Honors Program with one of the institution's largest scholarship offers and an invitation to immediately join its state-funded STEM pipeline program for underrepresented students, which ordinarily did not consider incoming freshman. (Cameron, a STEM persister and member of U-State's OP, was also invited to join the Honor's Program, shortly thereafter, an exceedingly rare case of a student entering through OP and impressing her professors and advisors so much as to be invited to join.) Sela grabbed the opportunity by the horns and never looked back; she is now a sophomore biochemistry major with a 3.8 GPA with an on-campus research internship in a biophysical chemistry lab. Sela, Cameron, and other students have formed their own sub-communities on campus to support fellow English language learner students; BELL alumni comprise the majority of these students, and a few others from similar backgrounds find such a sense of community from their BELL peers that they have shown up at a BELL alumni event.

Steve, who has spent over two decades as a senior admissions administrator in the state higher education system, saw such promise in working with BELL that he came to the school to visit classes and meet with BELL administrators, which helped lead to BELL's current dual-enrollment, college-credit course program. He developed such a desire to see more of these students succeed at his institution and beyond that he candidly spoke up during a presentation that the counselor/researcher was making with BELL's community-based organization partner at

a state conference, enthusiastically telling college representatives about these students in whom they should think twice about rejecting.

COLLEGE SUCCESS – AND STRUGGLES: ACCOUNTS FROM THE ROAD

BELL's relationships with colleges that have continued to develop and evolve over the years also set the stage for the unique privilege that I had to spend time immersed in BELL alumni's college environments, *in vivo*, originally as a natural progression from the school's college access work (referred to as "college success" advising in the first-generation college access world) and more recently as a means of gaining a more vivid portrait of how BELL STEM persisters and switchers, and students like them, are experiencing and performing in college. I visited twenty-four of the twenty-seven STEM persisters in college, as well as all ten of the STEM switchers who have remained in four-year programs, who attend a total of nineteen universities. Over the course of a few weeks in October and November 2015, I spent time with nearly fifty BELL alumni over the course of four bus trips zig-zagging back and forth across the state to the tune of over 2000 miles, not including a few rides from BELL alumni and college staff members.

This included visits with twenty STEM persisters and seven STEM switchers, as well as some of the advisors and other university staff who work with them. This was made easier by the presence of multiple BELL alumni at a number of campuses; in total, these twenty-seven students attend nine universities. Beyond a matter of convenience, some senior BELL staff members have noted that BELL alumni's clustering at a number of universities that have built a positive relationship with the school has also resulted in beneficial small "posses" of mutually-supportive students, to borrow from 1980s slang as well as the highly-acclaimed Posse Foundation, which for two decades has sent carefully crafted cadres of high-achieving leaders

from large city school systems to find great success at a host of elite universities (and which, perhaps unsurprisingly, repeatedly rejects BELL nominees to both its liberal arts and STEM programs). The following section consists of a selection of first-person accounts from the BELL alumni visits (including some of the encounters with the non-BELL U-State persisters, to support and extend the frame of reference beyond BELL alumni's own experiences) that set the stage for a comprehensive check-in as to how BELL STEM students are doing in college, followed by a detailed discussion and analysis of outcomes for the persisters (and switchers) to date.

I started visiting alumni from BELL's first class at their colleges because (a) I missed them, (b) I wanted to see them immersed in their new lives at colleges so as to keep up with their progress and continue to be available as a support to them (a goal shared by my principal), and (c) it provided opportunities for demonstrating BELL's interest in a given university, and the well-being of its alumni there, which could help BELL to build stronger relationships and to better understand who could be a good fit for the college in the future. These trips took on different forms and levels of planning over the years, from stopping with my parents to see Ramon – now a highly successful mathematics and math education major with very strong self-advocacy skills and self-efficacy whose peer teaching/mentoring exploits now include younger OP students at his school who now feels his advanced math courses are "easy, and not that much work once you know the professors" from frequent office hour visits and "chat with them about what they enjoy about the material" – on our way to New York City after a trip to the Baseball Hall of Fame to my father and one of my friends driving and moving Xiomara into college for her sophomore year. The early trips would include a couple Syracuse-area snowstorms. The first involved a BELL math teacher and me veering seven feet off the road into a snow ditch on the front side of a trip that closed with cheering on a member of the old six-pack

speaking up for increased OP funding at the state capitol. The other North Country winter adventure led to an unexpected extra day on campus where I dropped in and chatted with U-State's STEM pipeline program director, just after one of my former students came out of his office, who "heard I was in the area" after 200 miles of shuttered highway cordoned the already isolated area off from any other signs of civilization.

I carefully planned out itineraries to catch up with as many of our alumni at four-year colleges as possible by ensuring at least a day or two in each region with at least three BELL alumni sometime in 2015. For the October and November trips, I wanted casual time to see the students and follow them around a bit as they went about their business, and offering to help with studying as needed, but I also needed time to sit down and conduct final research interviews, even as I would ultimately find that much of the richest information came from their more natural interactions with me and with their peers on campus. The most intensive visit, eight days split over a two-week period, was with the "BELL North" crew, as we call it, at U-State and two neighboring campuses, where I was with twenty-one BELL alumni, including eleven STEM persisters and four switchers, plus the nine U-State comparison group students. This followed a couple days split between two campuses with eight alumni (five STEM persisters, one switcher, two non-STEM) in the Albany-Schenectady-Troy Capital Region. The last visit involved a day with three alumni (two STEM persisters, one switcher) in the Southern Tier region following a state PLTW conference a few hours east, in Binghamton.

Visiting Manuel and Abou

The BELL alumni are crucial in co-planning my trip itineraries. The idea for the Southern Tier trip transpired after I missed the opportunity to see those alumni briefly during a BELL "Crazy College Tour" to their campuses, and I sensed that two of the three students were

disappointed in me for chaperoning the other bus. I messaged Manuel on Facebook at 1:54am one night with the idea of coming to see him and the others after my PLTW conference, but that it would only work if he could help me find a ride to a bus station nearly an hour away the next day so I could get to Pittsburgh to surprise my parents for their anniversary. At 1:56am he responded that it was taken care of, that I could stay on the sofa of his campus apartment, and that one of his roommates who I had met last year was happy to drive me fifty miles west the next day. His buddies seemed like a relatively responsible group of guys, a mix of engineering, business, and liberal arts majors and a veritable league of nations at a university that had been one of the nation's first to be racially integrated, well before the turn of the 20th century. I knew we would have a good time together, save for his failing to mention to me that this time, in addition to late-night gaming sessions after they finished their essays and problem sets, one of his buddies was cat-sitting a kitten that liked climbing all over everyone, whether working or gaming or sleeping, at 2 or 3am. Naturally, this was all just part of taking in the context of college life for Manuel.

Manuel, who is now a senior criminal justice major, had switched out of engineering at the end of his pre-freshman summer Opportunity Program transition program, deciding there was too much mathematics required. He was not confident in his math skills, finding the expectations in this area to be overwhelming in college, and this combined with his finding the school's move away from a traditional electrical engineering program (I later learned that it was renamed and revamped to focus on renewable energy engineering, but this had not been clear to Manuel) led him away from engineering. (He had been admitted to the college as an undecided student, rather than engineering, due to his math SAT score of 400. The college's Opportunity Program had considered him in part because he broke 400 on both the math and

reading sections, a rare feat at BELL, even as a number of students had Regents scores and class grades higher than Manuel's.) Manuel reflected that the high salaries in engineering jobs had been one of his main draws. Primarily monetary motivations for entering STEM were mentioned with some frequency among students who would switch out of STEM, while these were curiously almost never the main driving forces for entering a STEM field among BELL alums who were persisters.

Manuel had initially struggled to find his footing in college, and the remote predominantly-white campus was a far cry from his neighborhoods in the Bronx and Santo Domingo, but he would ultimately find a group of friends, mostly from the track team (where he went from never running competitively in his life to being one of NCAA Division III's top 400-m competitors), and come to earn great admiration from his OP director, with whom I would chat during my visit, and the track coach with whom he had developed a close relationship. They had helped convince him to stay in school even after he realized he was becoming a father; indeed, by the time he messaged me last fall to come to the hospital to be with him and his ex-girlfriend, Xiomara, he was on the bus to New York City but firm in his resolve to return shortly thereafter to continue the semester. His OP director/advisor and I enjoyed reflecting on Manuel's incredible growth and the inner resolve that he now showed, but it was business as usual with Manuel during our visit, chatting with Abou – now a freshman at his college – and I about school and his job search from his work-study job at the university gym, and then hanging out at his apartment and talking about life and a little about the essay he was working on, as well as his concerns about taking a few extra credits by May to ensure his on-time graduation.

Manuel's OP advisor's impression of Manuel's grit and maturity arc raised her interest in future BELL applicants who met the university's minimum test score criteria to be sent over to

her office. This helped Abou to be admitted to the university's OP program, where he is now a freshman, a teammate of Manuel's on the track team, and had one of Manuel's roommate buddies as his summer program advisor (a young man with whom Manuel and I had a "study party" in the campus library together the previous time I had visited). Knowing that Manuel would be working when the bus would drop me off in the pitch dark – we ran good timing even after the bus driver decided to drop off one of the few other passengers in front of his house - Abou was waiting for me when I got off the bus and insisted on carrying my suitcase around campus until we got to the dorms. We went to see Manuel at the gym, I got to see a number of Abou's friends running and shouting out to the very low-key Abou (even passing one girl who spoke the same tribal language as he). We also stopped in a dorm lounge where his groupmates and classmates from Engineering Design class were putting the finishing touches on their bridge prototypes.

While energizing to see all the students coming together at night to work on their project, I also noticed that Abou's and Manuel's friends did not look like this group. The engineering students were nearly all white and male, while the rest of the time with Abou or Manuel, we generally spent time with a mix of black, Latino, Asian, and Caucasian students, guys and girls. Conversations about his experience there as a young man of color from New York City came up on a separate occasion with Abou, as well as with one of Manuel's Haitian friends and roommates who studies mechanical engineering. A sentiment shared by a number of BELL alumni in STEM fields at other selective universities, they noted how different the environment and expectations were here than back in their high schools, and the challenges that this brought. Abou was struggling immensely with his chemistry work, and following a D on his last exam, we had a two-hour chemistry study session together in the modest OP study lounge, where I could

see that much of the procedural and conceptual understanding of such topics as thermodynamics and electromagnetic radiation were eluding him. He brought a positive attitude and commitment to spend long hours in the study lounge, but I wondered about the quality of instruction and tutoring in chemistry based on the errors I was seeing; granted, I also realized that his chemistry and overall quantitative background from BELL had left holes that could be difficult to patch (especially with the uber-sequential nature of undergraduate science and math curricula). I would often find similar challenges and students feeling under-prepared and/or overwhelmed, with a matching volition to overcome these challenges, from working with alumni on problems or speaking with them about their experience in college so far.

The feeling among the guys I met at this school was one of students of color feeling like the interactions between students of different racial and ethnic groups were quite positive overall – Manuel's group of friends was more diverse than any others I have seen among BELL alumni across a number of campuses – but in the well-reputed engineering school, there were feelings of doubt, isolation, and self-consciousness at times. Mutual interests such as sports and video games seemed to draw students together here, and it was not a place where many students seemed to thrive on political discussions. Indeed, the college's student affairs office and senior administration had been active in placing signs and markers on campus promoting solidarity with activist student groups from the likes of the University of Missouri, but Manuel's roommates expressed that intercultural relations seemed positive on their campus and they wondered whether all the signs were necessary.

Visiting Khadija

Fati's best friend, Khadija, was having a very different social experience at her college, as I had discussed with her on Facebook threads and then in person during my visit to the

Capital Region. There were certainly some happy components to our visit together: we had an enjoyable time working Calculus problems to sharpen her differentiation skills and her ability to hone in on errors she was making on exams, and she had prepared a large bag of raw tapioca and other traditional West African breakfast foods for me to deliver to Fati at her college a couple hundred miles further north the following week. She had made new friends from her OP program and an African dance group, but there was a troubling racial divide on her elite liberal arts campus. Her college traditionally drew mostly white students from very privileged backgrounds and seemed to use its OP programs, including the institution's own program that did not have economic guidelines, to recruit promising students of color.

I have never heard or seen anyone observe or discuss this phenomenon, but I have found that some colleges' OP programs bring in low-income students from rural and urban areas of a wide variety of racial and ethnic backgrounds (including white students), while others looked at their programs as their near-exclusive means of improving racial diversity, with OP student bodies almost entirely comprising students of color from urban centers. Schools that take the latter approach to an extreme, exemplified by Khadija's school, seem to run the risk of producing doubly-divided student bodies, with multitudes of white students from very affluent backgrounds and overwhelmingly white schools, a small number of specially-recruited students of color from mostly lower-income homes, and virtually no students in the middle of this social Venn diagram (i.e. lower-income white students who are part of an OP program, or middle or professional-class students of color brought in as part of the regular admission pool). With this polarized student body, Khadija and her friends saw a number of white students marginalize the OP program students as a distinctly lesser "other." Finding common ground was unsurprisingly difficult in response to certain sheltered white students' overtly racist comments

on social media, at parties (including one that was not admitting black students), or to a roommate of color, and it is made even harder when so few of the students at this institution seem to be familiar and comfortable with individuals from backgrounds very different from their own.

While BELL is a high-poverty school with a student body comprising almost entirely non-white students, reflecting the social and economic segregation of so many urban schools today (also reflected by so many of the wealthiest suburban schools, with their own monolithic extreme), Khadija and other BELL students are confronted with engaging with students from cultural and linguistic backgrounds very different from their own, especially with the school's emphasis on group work. Having to find ways to interact and work together with individuals with widely varying native languages and cultural fabrics on a daily basis, as strong students like Khadija are tasked especially as leaders in their BELL classrooms, can foster a keen ability toward establishing common ground, a quality that is noted as an important strength within the dominant societal context of globalization today.

Indeed, one of the conversations that Khadija and I had in her dorm that day revolved around strengths that she saw from her experience at BELL, areas where she had an advantage over some of her peers. This was reflective of a number of the STEM persisters' tendency, or skill, in elucidating strengths where others would see only adversity or weakness. For Khadija, she noted that while her college friends' high schools had a lot more advanced classes, real science laboratories, and more of an understanding of college (largely from growing up here and coming from families and communities where college was the norm), there were some resources that she viewed as great strengths offered as part of students' experiences at BELL. In particular, she recognized that the close guidance that she received from her English teacher,

counselors, and others toward helping her to win scholarships and earn admission at a first-tier college were not a given at the schools attended by her new friends in college.

Visiting Juana and Arianny

When I met my former students' new friends at their colleges, the friends had often caught on to the idea that BELL was a different kind of school. That seemed to become even more apparent when they met and saw me around campus with my former students, waxing nostalgic about BELL memories or enjoying a joke, or talking about homework or just sitting and watching them interact (as some of them no doubt tried figuring out exactly what brought me to spend my evenings this way). A few miles from Khadija's school was a small women's college with eight BELL alumni, mostly in biological, nursing, and health sciences programs, where after I was welcomed to an OP "family meeting" by the program's director, one of Arianny's new friends walked up to where I had been seated, catching up with a couple BELL alumni, and smiled, "My name is Rosa. Thank you so much for sending me one of my new best friends here."

Arianny and the other BELL alumni are doing quite well overall at the college, and have attracted other immigrant OP students into their fold, as I would see at that family meeting and again in the dining hall and in the dorms (where I did not apply too much pressure in suggesting that their seven-hour mystery Netflix show marathon might not be the best environment for studying for an upcoming biology exam). Much of the BELL "family" there (one of the BELL alums who is now a senior had worked as summer program OP mentor for Juana, Arianny, and Ana, a 3rd first-year from BELL, and is very intentional about building a family-like atmosphere for the other young women from BELL) could have very easily ended up elsewhere, however, without the OP supports (and generally supportive science faculty) of which they came to speak so highly.

Most of the BELL students there did not technically meet the minimum test score criteria that the college generally requires for its OP students. Their OP director has been direct with me in how she went out on a limb in her belief in students from our first class, with her colleagues questioning her judgment, especially after they struggled mightily in the pre-freshman summer program. She saw a special kind of resolve, however, especially in the case of Karina, the young woman (a non-STEM major) who would eventually become the mentor for the most recent incoming class and who she would refer to as having taught her some of the most striking lessons of her professional career. Of the three students who are now first-years in her program, none were particularly close to the minimum 750 SAT benchmark, but she has learned to look differently at BELL candidates than the others in her pool, reaching out to me when she has questions or concerns. This included a day toward the end of the summer 2015 program where her colleagues felt Ana would not succeed at the college and that it would be best to take away her acceptance for the fall. Ana's fall semester showed her to be on solid footing as a Health Sciences major with an intensive tutoring and advising arrangement that the director devised. She did not quite have the institutional backing that Ajit enjoyed at U-State, but she came to have a deep belief in the grit and maturity of the older BELL alums – and was incredibly honest and open with me whether on the phone, in her office, or having coffee when she was sick (she did not want to miss an appointment to check in with me) – and the students' deep trust in her is palpable.

Visiting "BELL North"

"BELL North," as Cameron, the U-State and neighboring OP directors, and I call the absurdly disproportionate cluster of BELL alumni in the New York "North Country," has grown precipitously since Ajit accepted his first three OP students to U-State in April 2012. While I

enjoy the warm little extended BELL community that Karina leads on her campus, the BELL North community, especially its central core at U-State, takes on a character all its own that has made it one of my favorite places to spend time over the past year. Maybe it's the friendly fighting between BELL alumni with me over whose off-campus apartment will host me for that visit, or the shenanigans and good times that we relive at the BELL North dinners that I love hosting, or the conversation about the sociology of education that I had with one of my alumni hosts deep into the night. I think, however, that the magic I feel is the pride in seeing the fruits of so many years of so many students' labors, the collective hopes and experiences of students from all over the Caribbean, Latin America, and West Africa bound by their years at BELL, and the momentum that comes from the critical mass of all these students in one place.

I am a scientist by training and by nature, and there is nothing like watching the success of the experiment that Ajit, D, and their colleagues started with us a few years ago, with this community of students who most had labeled for full-time labor, a GED, or maybe community college, instead on track in Bachelor's degree programs in biochemistry, biology, public health, and engineering. I can almost see the weight of their school's, communities', and families' dreams and worlds upon their shoulders – just as I see the status quo looking for cracks and failures – in their 2nd or 3rd homes away from home, through the daily struggles with readings and homework sets and at-times delayed financial aid payments.

I spent eight days on these campuses this fall, mostly because I was expecting to meet and interview a few dozen non-BELL STEM persisters and switchers at BELL, and I knew that I also needed time to catch up with my twenty-one former students in the area. Cameron, Sela, and a couple of their friends who I had met during a prior visit ended up doing most of the successful recruiting for my comparison group, and like Ana and a few other students elsewhere, a number

of the BELL North students enjoyed asking how this research was going, as they were excited to share their experiences and also seemed to enjoy seeing me in the role of student. I was always trying to find ways to connect and build bridges with my students, and as the relationships often became more collegial and friendly after they graduated from BELL, there was this other connection that many seemed to feel from my being a student, too, especially one who was observing and studying them, and sometimes even spent time reading and studying alongside them.

At U-State, which served along with two groups of former students' off-campus housing as my home base for my time in the region, I was amused by the way that time flew each day between interviews, impromptu check-ins with alums who came by to chat, meetings with college staff members, observing a class that a professor invited me to observe that included four BELL alumni, and following former students who seemed to enjoy my tagging along with them and their friends. (There was a lot of texting back and forth as to when I would come back to which dorm to see which two or three students, etc.) The U-State OP office even reserved office space for me to work in during my visit, which was ironic since (a) I did not really work there and (b) my days up north, while full of ethnographic observations and activities, felt mostly like a vacation, outside of the structured interviews that "counted" officially for the research.

Some days, my "office" (U-State would sometimes reserve office space for me to meet with students during my visits) seemed like a revolving door of former students and their friends coming in for interviews or just to chat about how classes and college life were going. Students who I originally met from interviewing them for my comparison group would say "What's up?" to me on campus, on their way to or from class or the OP office or writing center. In one case, a young man who had met me the previous week saw me outside of the student services building,

talked with me about his coming from Friday jummah prayers at the mosque with "your boy Rahman" from the engineering school, and added, "Yo, you must really like it up here, you're back again!"

On days that were not as busy, Ajit welcomed me to sit next to his office, or even to use his office if need be. (On my last day on campus before leaving, his son was sick, so he had me over at his house for tea to check in once more before I left about our little experiment four years in the making.) In the OP office, I would often see a former student, or two or three, walking through the area, and they introduced me to Ajit's colleagues, the OP advisors, one of whom decided to call a meeting with me to talk about BELL and about students from U-State or nearby institutions who I knew who might be interested in an immigrant voices' creative writing project that she was preparing. Evenings were split between spending time off-campus with my hosts and in the on-campus dorms with the underclassmen.

One particularly eventful evening started with relaxing and sitting with a few freshmen in their dorm lounge, at which time Sela and another BELL alum walked by on their way to Sela's room for chemistry homework. I had not seen Sela's friend around campus much yet, and I heard "chemistry studying," so naturally I followed them, although I knew my three students at the nearby engineering school were also expecting me for a chemistry review pow-wow that evening before their exam the next day. Sela was helping her friend, a BELL alum who was now a U-State freshman, trying to tutor and motivate her to improve in General Chemistry, but on this night she had her own Organic Chemistry lab write-up to work on from a chromatography experiment. She went to her lab professor's office hours frequently to try to improve in the course – anything outside of an A and total understanding of a topic was a disappointment for Sela, now as always – and she was amused when we had pieced together that her lab professor

had completed his PhD at Brandeis with a professor who I had years later for Organic Chemistry lecture. We talked about the material and about lab report structure, interspersed with the noise from her roommate's home hair salon equipment and as she and her friend brought me up to speed on the latest hair extension styles among West African women, their disdain for their hallmates' marijuana habits, and their concern over many of their male friends and classmates from BELL getting involved in too much partying and the consumption of certain substances related therein. (It was a reprieve from some of the housemate drama that I would hear, or on which my advice would be sought, from one side or the other at my hosts' apartments or on a late-night supermarket run, but overall, I embraced feeling so included in what was going on around me.)

I got carried away among all the conversations, a common "challenge" when I am catching up with alumni, and saw that I was running late for my walk across town and a river to the engineering university's Science Center. I arrived around 9:45pm, found my crew of Ignacio, Rahman, and Tamana, and we found an empty classroom to set up shop for a late-night study session. I felt energized seeing so many students out and about and studying in the Science Center late into the night, and I liked the fact that the OP office (whose very dedicated staff had left after a long day by 5 or 6pm) was integrated along this very hallway near the science faculty's offices and classrooms and student workspaces (and a student-run coffee shop, of course). As had been the case so many times before, Tamana was feeling nervous, although now it was with tangible reasons, as she, a math and science super-star at BELL, had received multiple early warnings from professors at the recent mid-way point of the fall term, including all three courses for her engineering major.

We spent time working out problems and discussing strategies and key vocabulary, at their desks and the blackboard, about basic quantum chemistry and electromagnetic radiation, but overall our two hours together were a combination of chemistry tutoring, general check-ins, and motivating each other (plus a little speech by me as we wrapped up the session and walked the students back to their dorm quads). The students enjoyed their chemistry professor and his engaging demonstrations, but being in a class of 200 students was a struggle, especially when many others seemed to have seen most of the material before. Going to TAs' office hours seemed to be a key strategy to dealing with the large math and science classes, as was getting a peer OP tutor when necessary. As was mentioned by BELL students and the comparison group beyond just this university, there was a wide range in how helpful a given tutor, TA, or professor was, depending on such factors as whether they would take their time to give step-wise explanations and whether a given professor seemed interested in "going beyond" the bare minimum of transmitting large amounts of information to attempting to grab students' attention and make the material interesting and relevant.

BELL had never sent one, let alone three, students to a competitive engineering school before, a place where large lecture halls for freshman classes were mixed in with abundant experiential learning opportunities on and off campus to result in career opportunities that rivaled the Ivy League, and having already "crossed the bridge" to success at the likes of U-State, these very top students' success at a place like this – like those of Fati and another BELL STEM superstar at the prestigious liberal arts college nearby (where I also spent a little time just before a chemistry midterm exam, and also spent some time chatting with two of the chemistry professors themselves) – was our next big challenge and proving ground if we were to continue to cultivate hopes and dreams for future generations at BELL.

Overall, while they have had to maneuver serious obstacles in their paths, the STEM persisters continue to find successful ways to do just that: persist. They utilize skills from prior educational experiences from their BELL years and beyond, from extensive academic, social, and cultural support systems in college (especially those under the umbrella of personalized, skillfully run OP programs), and call on keen senses of self-efficacy, growth rather than fixed orientations to their own learning, strong internal loci of control, and strong social ties and commitments to give back to their communities, many of which seem to stem from long, steady practice encountering and conquering adverse circumstances. These past two chapters sought to introduce many these characteristics through richly contextualized narratives, while the next chapter presents a portrait of the persisters, with some comparisons to the switchers, with a comprehensive review of the themes that arose to unpack various aspects of their journeys over the past several years.

Chapter 7

KEYS TO STEM PERSISTENCE: CRYSTALLIZATION AND DISCUSSION OF FINDINGS

While it is impossible to meaningfully present every nugget of insight gathered from following these students and their trajectory from their arrival to the US and BELL high school, the transition to college, and college itself, this chapter aims to paint a comprehensive portrait of the STEM persisters, with comparisons to the switchers when possible, and to distill the key themes embodying the experiences, relationships, internal characteristics, and other factors that formed or informed their navigation toward success in pursuing their STEM-related majors and career goals. Due to the study design (and namely, the sample size) and the impossibility of assigning causality in comparing persisters and switchers, most of the quantitative data will be presented with comprehensive descriptive statistics, with statistical tests of inference used in only a few specific cases to highlight specific characteristics in line with particularly poignant qualitative findings that may warrant further investigation in future research. While the research aims to draw insights from the experiences and characteristics of the students who switched out of STEM to better understand what might have helped them persist or how they may have been fundamentally different from those who persisted, the dominant arc throughout this outcomes chapter, following from the original research questions, focuses on extending the deep, complex understanding of those who have persisted.

PORTRAIT OF THE ORIGINS AND BASES OF STUDENTS' STEM INTERESTS

Tables 7.1 and 7.2 highlight the common origins of students' interests and primary motivators for the career goals they set for themselves. First, the themes in 7.1 summarize an earlier discussion from Chapter 5, but with an extension beyond just the BELL STEM persisters.

A core value and motivator of wanting to help others was very common across BELL and U-State persisters and BELL switchers. A number of BELL switchers went into detail extending this general concept of helping people to a notion of social responsibility, to give back to one's family and/or community. For some, this was rooted in an illness observed among a close family member, problems with health care across the community, or a personal experience being sick and spending a lot of time in clinics or hospitals. This theme was especially central among students who wanted to pursue careers related in some way to medicine or biomedical sciences, which comprised a large portion of all three groups of students.

Table 7.1
Evolution and Origins of BELL STEM Persisters' Career Interests: Common Themes

Social responsibility / giving back to family and community * ^
Overarching interest / enjoyment in science and/or math topics ^
Self-efficacy: feeling "good at" science/math
Role model in community or extended family in home country
Inspired by a classroom experience
Curiosity/enthusiasm about new discoveries and/or technologies * ^

*Also a common theme among BELL STEM switchers.
^ Also a common theme among U-State STEM persisters.

A number of students across all three groups also expressed interests stemming from a sense of excitement and wonder around new technologies and scientific discoveries that they heard about or dreamed to be possible; these students were often interested in science research careers and/or engineering and technology careers, more so than careers in health care. A broad interest and enjoyment of science, of "doing" science vis-à-vis experiments, problems, and/or other contexts in or outside of school was characteristic of persisters from BELL as well as U-State, but was not commonly discussed among those who switched. Outside inspiration, from a

role model in one's extended family (often an aunt, uncle, or cousin) or from a classroom experience, also emerged as a theme among BELL persisters. A sense of self-efficacy, of feeling confident in one's ability to do science, sometimes starting from doing well in these classes in grade school, also contributed to the early interests of a number of BELL persisters. An examination of BELL STEM switchers's reflections on why they previously wanted to enter science fields demonstrates a common theme, in particular among those interested in computer science, engineering, and technology fields, in the economic benefits of the jobs in these fields, namely their attractive job prospects and salaries. While these considerations entered into the minds of persisters, the seeds of their interest were more firmly rooted in the altruism of social responsibility and feelings of interest, inspiration, and excitement for science (and sometimes math).

Table 7.2
Contributing Factors to Students' STEM Career Goals

	BELL STEM Persisters	BELL STEM Switchers
Curiosity to learn and discover new things about the world	3.5 $\pm$ 0.7	3.4 $\pm$ 0.7
Potential for helping people	3.8 $\pm$ 0.4	3.4 $\pm$ 0.7
Job security / job prospects	3.6 $\pm$ 0.6	3.7 $\pm$ 0.5
Salary	3.0 $\pm$ 0.8	3.6 $\pm$ 0.5
Enjoyment of doing science/math	3.5 $\pm$ 0.7	2.8 $\pm$ 1.1
Having meaningful relationships with professors and peers in the field	3.2 $\pm$ 1.0	3.0 $\pm$ 1.2

Notes: Based on 1-4 Likert scale ratings. Quantitative data are given in the format of mean $\pm$ standard deviation. n = 27 for persisters, n = 10 for switchers data.

Second, Table 7.2 provides quantitative data reflecting the importance of several different factors in STEM persisters' choice of their STEM career goals and STEM switchers' prior STEM career goals (i.e. recalled retrospectively, considering their motivations before they switched). While this table reflects students' motivations for their current career goals, some patterns may be observed that track back and relate to the origins of students' interests from Table 7.1. A one-way ANOVA analysis revealed statistically significant differences across the six potential contributing factors to students' STEM career goals ($p = 0.0007$, $F = 4.559$). Bonferroni post-tests (which are quite conservative) yielded significant differences between two pairs of contributing factors at the $\alpha=0.05$ level; for BELL STEM persisters, potential for helping people was significantly more important toward their career goals than salary (the strongest relationship observed) and having meaningful relationships with professors and peers in the field. This last relationship might suggest the primarily internal motivation and intrinsic characteristics that these STEM persisters bring to the table, although the persisters still granted a good deal of importance to this variable, with a mean of 3.2 on a scale of 1-4.

Only ten STEM switchers (i.e. all of those who remained in four-year colleges) completed the comprehensive switchers questionnaire, and with this small sample, it is difficult to draw any definitive conclusions from the switchers' quantitative data; however, one can note that the relative importance of factors they had considered in pursuing a STEM career was somewhat different than those who would persist. Job security/prospects (granted, the second-highest-ranked variable by persisters) and salary (ranked least important by persisters) were the two most important factors to those who would switch, with enjoyment of science/math perhaps not surprisingly the least important driving force in their minds.

The small number of responses or available data among U-State persisters for these and other data to be presented in this chapter (n=7-9 depending on the item) is such that inferential tests of these students were not run against the BELL STEM persister group. They are not included in summary tables comparing persisters and switchers, but with the limited sample obtained, some trends were observed, and will be discussed, with the understanding that further data would be needed to demonstrate statistically significant relationships. Like the BELL STEM persisters, and as reflected in the discussion from Table 7.1, the U-State STEM persisters' top consideration in spurring on their STEM career goals was potential for helping people, with a 3.9 average out of a maximum 4 reflecting a set of U-State responders who each answered "4" with the exception of one person who indicated "3." Meaningful relationships with professors and peers in the field were the second most important factor to this group, and salary was by far the least important, with an average of 2.0, nearly a full point lower than the next-lowest rated factor and the only factor with an average below the Likert scale midpoint (2.5). Salary's last-place finish among both BELL and U-State persisters, and its near-top finish (with job prospects/security) among switchers seem to confirm the qualitative findings from students' open-ended responses about their early motivations (see Table 7.1).

PORTRAIT OF BACKGROUND AND HIGH SCHOOL CHARACTERISTICS

With an analysis of students' motivations for pursuing STEM careers in hand, the next step in constructing their "portrait" lies in examining background and high school characteristics of the STEM persisters and switchers, which were introduced in Chapter 5 and are presented through comprehensive descriptive statistics in Tables 7.3 and 7.4. A cursory look at these tables shows the BELL persister and switcher groups to look similar in many ways. In terms of background characteristics, both groups arrived in the US as older teens and graduated from high

school when they were about three years older than is typical for typical US teens. Students from both groups tended to decide on pursuing some kind of STEM-related career goal as teens, but the seed was planted a couple years earlier, on average, among would-be persisters, such that most of them were already strongly considering such a path before they immigrated. Well over half the members of each group recall enjoying science and/or math by age ten, while curiously, just under half of each group refer to themselves as naturally drawn to an interest in science or math (with the remainder feeling more in line with having been led to an interest in STEM by someone or something external to themselves).

Table 7.3
Background Characteristics

	BELL STEM Persisters	BELL STEM Switchers
Gender: % Female	55.5	35.7
Race/ethnicity: % Latino/a	48.1	78.6
% West African	37.0	14.3
% S/SE Asian	14.8	7.1
Age upon immigration	17.4 $\pm$ 1.2	17.6 $\pm$ 0.7
Age at HS graduation	20.7 $\pm$ 1.1	21.1 $\pm$ 0.8
Age of deciding upon STEM career	14.5 $\pm$ 3.1	16.5 $\pm$ 5.8
Mother's yrs. of schooling	9.8 $\pm$ 4.2	10.5 $\pm$ 5.2
Father's yrs. of schooling	10.9 $\pm$ 5.3	12.4 $\pm$ 6.6
% of Parents with (at least) HS Diploma	51.8	52.2
% of Parents with (at least) BA	14.8	29.6
% with biological parents married	29.6	28.6
% raised by both parents (home country)	22.2	0
% with $\geq$ 1 same parent(s) in home country and US	37.0	23.1
Hrs. of school day in home country	6.1 $\pm$ 1.6	n/a
% with school day $\leq$ 5.5 hrs	44.4	n/a
Median household income of NYC zip	\$33,686 $\pm$ 10,480	\$32,195 $\pm$ 10,149
%ile SES rank of NYC zip	24 $\pm$ 21	23 $\pm$ 22
% who loved math by age 10	48.1	50.0
% who loved science by age 10	40.7	70.0
% who loved math and/or sci. by age 10	66.7	80.0
% "naturally drawn" to science/math	44.4	44.4

Table 7.4
High School Characteristics

	BELL STEM Persisters	BELL STEM Switchers
HS GPA	89.8 ± 4.9	85.5 ± 7.5
HS Science/Math GPA	88.4 ± 6.3	84.4 ± 7.2
% in top 15% of class	55.6	28.6
SAT Math score	423 ± 96	374 ± 73
SAT Math + Reading score	778 ± 127	737 ± 131
Regents Algebra I score	78.8 ± 7.3	75.9 ± 5.6
% who took ≥ 1 College Now Math	33.3	7.2
% with HS lab research internship	40.7	28.6
HS STEM Challenge Index	2.3 ± 1.7	1.6 ± 2.1
% with STEM Challenge Index ≥ 3	37.0	14.3
% who tutored peers in math/sci at least weekly	63.0	30.0
Hrs/wk of science HW/studying	4.6 ± 1.7	4.3 ± 1.8
Hrs/wk of math HW/studying	3.8 ± 1.8	3.1 ± 1.6
Hrs/wk of other HW/studying	4.3 ± 1.9	3.5 ± 1.7
Hrs/wk HW/studying at school after School	4.4 ± 2.1	4.1 ± 1.6

In terms of family, among both STEM persisters and switchers, just under 30% have biological parents who are married, and as is typical of immigrant children and adolescents today, most students from both groups did not live with the same parent(s) before and after their immigration or spend most of their childhood with both parents, although this was somewhat more pronounced among switchers, none of whom were raised in their home country by both parents. Just over half of the parents in both groups had at least a high school diploma (51.8% and 52.2% for persisters and switchers, respectively), far lower than the 90% figure among all

adults in the US. Likewise, both groups showed far more of a spread in terms of years of prior education than is typical among American families, but is quite typical among US immigrant populations today (Suarez-Orozco & Suarez-Orozco, 2001); that is, from the large standard deviation, and moreso from examining the raw data, one finds a very wide spread from a number of parents with no formal education whatsoever, to some who attended elementary school (these first two categories being especially rare among native-born Americans today), to a number who attended or graduated high school and a smaller number who attended or graduated from college, and occasionally graduate school.

As an extension of this large degree of variation, albeit somewhat unexpectedly, college graduates are actually slightly overrepresented among switchers' parents relative to the American population at large. Furthermore, one might expect persisters to come from more educated families, but the switchers' parents' 29.6% college graduate percentage is exactly double the 14.8% among parents of persisters. (Another layer of complexity, not introduced here but which could be invaluable in future studies, would be to consider educational backgrounds of extended family members, especially as these individuals often raised the students as children, and many of the students' home cultures view core family structures more expansively than the nuclear family that is considered standard or the status quo among the dominant culture in the US (Suarez-Orozco & Suarez-Orozco, 2001), and as such dominates considerations in social science studies.) In terms of neighborhoods where students' families settled in New York, they tended to be within zip codes across the lowest and second-lowest quintiles in terms of socioeconomic status (as rated by income and education status of residents), and with median household incomes at the higher end of the income range of the families themselves.

Students across both groups encountered and overcame various social traumas over the course of their immigration experience, as well as in their lives in their home country and in some cases with very trying economic and familial situations in New York; overall, however, students from both groups were able to make adjustments and acculturate in such a way as to bring their internal strength, resolve, and values (which will be discussed in more detail shortly when parsing out students' experiences up to the present *in* college) to find success in navigating a new educational and cultural system as older high school students, with both groups on the surface demonstrating solid B-averages or higher. Looking in a more detailed fashion at the two groups, though, one sees a number of differences emerge.

For example, before considering high school performance and habits, one may note that the gender and racial/ethnic breakdown of persisters and switchers looks different. The STEM switcher demographics roughly mirror BELL school-wide demographics, except that females represent about 39% rather than 36% of the student body, West African students represent 15-18% rather than 14% of the student body (and are not quite as dominantly from Francophone countries, unlike all but one West African student across both groups in this study), and South/Southeast Asian students represent about 4% rather than 7% of the population. While it is true that these tweaks would be needed to mirror the school's true population, the switcher group is far closer to overall school demographics than the persister group, in which West African students from Francophone countries (i.e. those where French is an official language due to prior ties to French colonialism – French is not these students' first language) and South/Southeast Asian students represent more than double their relative schoolwide population, and Latino/a students and males are relatively under-represented. (Demographics of BELL graduates at large would also differ from schoolwide demographics due to widely differing graduation rates among

sub-groups. Females are relatively over-represented among graduates – and among students with A or B averages – relative to enrolled students, as are Francophone West African students, with Latino (males) the most under-represented among graduates and among those with A or B grades.)

Prior research and college admissions practice suggest that such factors as high school grades and test scores should be higher for students who "make it" in STEM fields, so statistical tests were performed to evaluate for differences between the two groups along these characteristics. One might also wonder, however, how much of a difference one could be expected to see when nearly all the students in this study were so far off in the periphery from the "screen" of STEM majors that four-year colleges generally admit into these areas of study (in terms of SAT scores, and in terms of how seriously they would look at these students' high school GPA given the courses offered, or not offered, at BELL). Ultimately, comparing descriptive statistics will be the primary mode of discussion of differences, as the small number of switchers, in particular, makes it more difficult to find statistical significance in comparing the persisters and switchers across a given characteristic, especially given the relatively low power of t-tests, and especially Chi-square tests.

A statistically significant difference was found between the two groups in overall high school GPA, where persisters' 89.8% average was found to be greater than switchers' 85.5% average via t-test at the $p<0.05$ level ($t = 2.188$, $df = 39$, $p = 0.0347$). Similar trends were observed with persisters having higher high school science/math GPA, higher Math Regents scores, and higher SAT math scores than switchers, but the differences were not significant at a level of 95% confidence. The same was true for the approximately two-fold or greater differences observed among persisters versus switchers who ranked in the top-15% of their

BELL class (essentially, an A- average or higher), or who reported tutoring peers in science and/or math at least once weekly in high school, which included an impressive 63% of persisters versus 30% of switchers. Likewise, fully one-third of persisters completed at least one College Now math course, which several would cite as vital to their preparedness for college, versus a total of just one switcher. Persisters also reported completing slightly more homework in each subject, and staying after school slightly longer, than switchers.

As many persisters would go on to refer to the importance of challenging and engaging STEM learning experiences outside of the regular BELL class offerings in preparing, a HS STEM Challenge Index was constructed to provide a measure of challenging courses or other high-level STEM learning experiences to which students were exposed during their years at BELL. A value of one point was assigned to a student for each completed course or school year of each of the following: Regents Chemistry course (with passing score), College Now math course, College Now science/engineering course, advanced/dual-enrollment College Science course, Project Lead the Way course/program, weekend STEM enrichment course program, and summer laboratory research. The incidence of students with a STEM Challenge Index of at least three was nearly triple among persisters (37.0%) versus switchers (14.3%), and 83% (ten of twelve) students with such a score would eventually persist.

Comparing mean STEM Challenge Index scores between persisters and switchers did not yield statistically significant results, but a confounding factor was that the two highest-achieving switchers accounted for nearly half (twelve of twenty-five, including eight for Angela alone) of the total Index points of the entire group of fourteen switchers. Exact Index scores could not be calculated for the U-State persisters, but it was observed that while a number of them had access to more advanced coursework within the scope of their regular high school schedule than BELL

students, none of them had experienced early exposure to scientific research, during high school, an opportunity with which many BELL students had been presented and of which they had taken advantage.

PORTRAIT OF PERSISTERS AND SWITCHERS IN COLLEGE

Following this analysis of students' high school experiences and characteristics, the discussion now follows the students in college: what are they studying, how are they doing, what are some of the successes they have had and the obstacles that they have encountered, and what are the key strengths, experiences, and understandings the persisters have brought with them to carry them through while others switched out? This discussion is opened by examination of Table 5, which shows a breakdown of students' STEM majors (or originally planned major, in the case of STEM switchers), and Table 6, breaking down a variety of quantitative characteristics of students' college experiences.

Table 7.5
Distribution of College Majors

Major category	No. of BELL STEM Persisters	No. of BELL STEM Switchers (Major before switching)
Engineering (Mech., Comp., Civ.)	4	1
Information Technology / Comp. Sci. / Engineering Technology	5	6
Mathematics	1	0
Biology	5 [(3 PM)]	3 [(2 PM)]
Other biomedical/biological sciences (Biochemistry, pharmacology, etc.)	3 [(1 PM)]	2 [(1 PM)]
Other health professions (Nursing, health sciences, PT)	4	1
Public health	3	0
Undecided STEM	2 [(1 PM)]	1

[PM]Indicates a student who is also an aspiring pre-medical student (includes students considering careers as a physician, dentist, and physician assistant).

Table 7.6
Summary Characteristics in College

	BELL STEM Persisters	BELL STEM Switchers
% who sees him/herself as having a STEM mentor(s)	88.9	70.0
% who still speak with a HS STEM teacher/mentor at least monthly	51.9	n/a
% of students' closest friends pursuing STEM	45.9	19.0
Change in STEM interest from 10th grade to present (Likert, 1-5)	3.8 ± 1.1	n/a
Self-rated retrospective preparedness for college science from HS (Likert, 1-4)	2.7 ± 0.9	2.7 ± 0.5
Self-rated retrospective preparedness for college math from HS (Likert, 1-4)	2.4 ± 1.1	2.5 ± 0.8
College GPA	2.92 ± 0.52	2.72 ± 0.66
Relative selectivity of college (1-40, Princeton Review scale)	24.4 ± 6.2	21.6 ± 6.2
% in extracurricular STEM club, job, or other activity in college	59.3	0
Hrs/wk studying/HW in college	20.2 ± 11.5	14.6 ± 17.4
Hrs/wk in study groups in college	2.8 ± 5.7	n/a
% receiving Pell grant	100	100
% economically eligible for OP	88.9	85.7
% matriculated to an OP	66.7	71.4

First, as is evident from Table 7.5, most students are clustered around two specific sectors within STEM: (a) biological, biomedical, and health sciences and (b) engineering and technology fields. (The students who were recruited to the U-State persister comparison group comprises mostly biology and biochemistry majors; biology is the most popular STEM major at U-State,

and one of the campus's most popular majors overall.) The persisters and switchers in the engineering and technology majors are almost entirely male, with the exception of Tamana, a civil engineering major. The health professions and public health majors are entirely female, and the remaining students are a mix, but mostly female. In terms of high school performance, the students who performed strongest at BELL are clustered between engineering persisters, other biomedical/biological sciences persisters (and two switchers), and pre-medical undecided and biology persisters. The persisters and switchers with the lowest BELL GPA tended to be clustered around information technology and engineering technology majors.

Most persisters have remained in the same or similar major, to date, as they intended upon entry, with the exception of the three public health majors, who were considering biology majors upon entry but found the "gateway" science courses taken by fellow biology and pre-medical students to be overwhelming as freshman and were then guided toward the public health major (which can also serve as a pre-health professional program, such as in nutritional sciences or physical therapy). One could argue for the exclusion of this major from being considered STEM or STEM-related, but my position is that it is a hybrid major that explores scientific and biomedical problems from an interdisciplinary perspective, with coursework across the natural as well as social sciences.

As one can see from Table 7.6, most students in the study have college GPAs in the low to mid-B range, with persisters showing a slight (non-statistically significant) edge by 0.20 points (the equivalent of a mean of a B- average versus persisters' nearly mid-B average). As indicated by standard deviations larger than one-half of a letter-grade, there is considerable variation in students' performance in college. Nearly all students, persisters and switchers alike, cited some challenges and overwhelmed feelings at times during their college careers, with the

obstacles faced and successes experienced varying within and across institutions with different admissions selectivity/competitiveness and arrays of available support systems, as well as between students who were or were not part of Opportunity Programs.

On the whole, students tended to matriculate to four-year colleges and universities in the middle or slightly-above-middle range in terms of admissions selectivity and graduation rate, albeit with a fair degree of variation, with STEM persisters attending slightly more selective universities than switchers, most attributable to more of them having reached certain test-score thresholds, and secondarily having earned higher grades, than the switchers. There were notable exceptions, however, namely Angela – arguably the strongest candidate in BELL history based on credentials at the time of entering college – whose frustration with the ultra-competitive, uber-individualistic, gatekeeper-filled culture of science at her elite liberal arts college drove her away from the sciences after three semesters. A few male persisters and switchers went on academic probation for one or more semesters of college. This led or helped lead to three switching decisions, and the two persisters who found themselves in this situation will require extra semesters to graduate. Both of these students shared their consequent emotional and financial concerns with me, as well as the firm resolve with which they responded verbally and then with their actions to refuse to give up on chasing their dreams. While at times a formidable struggle, they maintained this resolve even when their advisors or others at their colleges did not provide a lot of support or suggested they leave the sciences.

ADDITIONAL DOMAINS FOR FURTHER CONSIDERATION

As part of the nature of engaging in this type of critical ethnography, the ethnographer's own voice is privileged even in trying to give voice to the participants and the environments in which the ethnographer was immersed. Some dimensions and domains of interest may not have

been fully interrogated in the course of this study. More extensive consideration of these domains would certain merit further study in the future; here they are but briefly introduced.

First, while the population under investigation is primarily referred to throughout the text as English language learners, over the course of the study, the language surrounding these students continued to evolve such that "emergent bilingual" (Garcia, Kleifgen, & Falchi, 2008) is the preferred term in many circles. As a researcher aiming to engage in strengths-based perspectives to the students in the investigation, I recognize that the term "emergent bilinguals" - or the new term that I would like to coin, "emergent multilinguals" in reference to many of the students speaking more than two languages - recognizes students as developing mastery of an additional language while implicitly valuing their native tongue(s). On the other hand, the term English language learner, while flexible in describing students with proficiency in any number of other languages, privileges the position of the English language and does not explicitly attach value to students' native tongues.

Second, as a researcher engaged in a critical ethnography, with a study particularly focused on the experiences of the students, I did not fully explore the impact and relationships of parents with the students in the study. In particular, at this juncture I wish to at least make mention of the significance of the parents' roles and experiences to their children's experiences, as their backgrounds and the networks and capital to which they did or did not have access certainly impacted the study. In general, as discussed in chapter five, while some parents did not finish elementary or middle school, about half of the parents had graduated from high school in their home country. Without a command of the English language or extensive familial or other networks in this country, however, even these parents, and often the one-seventh who had a college degree, generally did not have access to significant social, cultural, or financial capital in

this country to fully capitalize on their own skill sets or to direct assist their children's educational and professional trajectories. A number of families had been more along the lines of the middle class of their respective countries, which did not require the same level of education as is increasingly the case in this country, and most of the parents engaged in long hours working such jobs as home health aide (for the mothers) and livery car drivers (for the fathers).

Furthermore, most of the students did not live with the same parent upon arrival in the US as the parent or other adult family member(s) who raised them in their home countries, a phenomenon that was at once part of the social traumas that are commonplace among immigrant youths and adolescents today and which often strained the closeness that they may have otherwise felt with their parents. Even outside of this, however, the vast majority of the parents' very limited access to the types of resources and capital that are dominant in access and success in higher education, in general and in STEM in particular, helps make the argument for the importance of the type of research and framework employed in this study, to focus on the students and how they explored and gained social and cultural capital in their high school and college years.

Finally, I wish to clarify the framing and role of considering the STEM switchers in this study. A primary objective of this study resided in exploring how to best support underserved youth in gaining access to STEM opportunities to maximize postsecondary success in these fields. This aim was constructed in recognition of the extensive possibilities and rewarding career opportunities available to individuals with a strong STEM background, and in light of the extreme inequities of educational opportunities that continue to block some students from a fighting chance at pursuing such paths. Furthermore, strong skill sets and experiences in STEM disciplines are in line with the continued evolution of twenty-first century skills in our

increasingly globalized, technology-driven society. While explicitly recognizing this perspective, it is imperative for me as a researcher that the reader does not perceive the STEM switchers as being "othered," as failures or as unlikely to have viable career options. The ten switchers who formed the crux of the switcher comparison group all, in fact, persisted in other fields in four-year colleges, and for at least several of them, their persistence among the rigors and challenges of their four-year colleges points back to the relationships and experiences they built up as part of the development of the aforementioned STEM-related skills and proficiencies.

APPLYING OBSERVATIONS AND FINDINGS TO DISCUSSING EXPERIENCES AND RELATIONSHIPS THAT MOVED STUDENTS FORWARD

Overall, most the persisters have found at least one supportive adult at their college, often in the form of an OP advisor or director whom I have come to know as a strong and unwavering advocate, but over half of STEM persisters also still speak with a science or math teacher or mentor from high school at least once per month. These continued relationships with high school mentors was not explored in depth with switchers or U-State persisters but seemed to be characteristic mostly of BELL persisters; U-State persisters did not report the kinds of strong mentoring and advising relationships, toward their STEM goals or in general, from high school as were reported widely among BELL students.

Most STEM persisters from BELL, as well as from U-State, got involved outside of the classroom in activities related to their major and career goals, most commonly as peer tutors for freshman science or math courses, and sometimes through state-funded STEM diversity pipeline/access programs available or other activities such as on-campus research, volunteering at a hospital or clinic, and/or being part of a club related to one’s major. Laboratory research experiences in college were mentioned and described with enthusiasm and detail by a number of

U-State students; like the vast majority of college students, and certainly those from most urban public schools, they had not been exposed to research in high school, unlike a number of the BELL students who had been involved in the likes of Project SEED at a time when they had a significantly more limited scientific background but were in the earlier phases of formalizing their career goals. The instrumental nature of these exposures to research by the middle of students' undergraduate careers or earlier is consistent prior educational research exploring this very issue and its relationship with student persistence in STEM. This work has been led by Elaine Seymour, the same researcher who facilitated the groundbreaking 1990s *Talking About Leaving* study (and the upcoming follow-up *Talking About Leaving* study) of STEM persistence and switching that helped guide the development of this study (and who shared invaluable insights and resources with me after I "cold-called/emailed" her and one of her colleagues) (Seymour & Hewitt, 1997).

Additionally, having close friends in STEM, from high school or college or other settings, was associated with persistence in STEM with statistical significance; when students were asked to describe what their (up to) four closest friends were doing in life, 45.9% of BELL persisters' closest friends were in college (or already graduated) pursuing at least a Bachelor's degree in a STEM-related field, compared to 19.0% of switchers' closest friends ($\chi^2 = 5.155$, $p = 0.023$). The direction of this relationship can certainly be debated, but consistent with Maton et al's (2000) and Graham et al's (2013) persistence frameworks, having a strong peer network with similar interests seemed to spur students toward success from a number of BELL and U-State persisters' discussions (and my observations of many of the BELL students over the years) of how instrumental helpful friends and other peers have been to their acclimation and success.

As mentioned earlier and shown in Table 7.6, all of the BELL participants received Pell grants and the vast majority were economically eligible for OP programs. Fully three-quarters of eligible persisters, and an even greater proportion of switchers, were admitted and matriculated to such a program, about half to private colleges that are somewhat to quite selective. This is notable in that it so far exceeds a student's chances given the approximately ten-fold difference between eligible students and available spots, and is key to the college access approach of BELL for the added supports that students receive on campus – helping them to acclimate to the demands of their college and equipping them with tools that can largely be characterized as building their social and cultural capital – as well as the extremely generous scholarship and grant aid that comes with it.

It is common knowledge that the cost of college is spiraling out of control in this country, and much has been written in recent years about first-generation and low-income students often being scared off from applying to colleges from their listed "sticker" price (Bowen, Chingos, & McPherson, 2009). Opportunity Program funding at the colleges attended by these students (supplemented with additional external scholarships in a few cases) is such that at the private colleges, students have full tuition (to the tune of $30,000-48,000 per year) and the majority (generally 60-90%) of room, board, and books paid for by grants and scholarships. With this level of funding, their loan burden is lower than the national average and they feel less pressure to work long hours. A similar deal is in place for those in an OP at public universities, such as U-State, albeit with a slightly larger loan burden, but for all of the OP students, as well as the other students, generous funding was critical to their entrance and success in college, as they indicated from qualitative responses as well as very high ratings they gave to the level of financial aid received, which is included in Table 7.9 later in this chapter.

In terms of their experience in their college classes, BELL STEM persisters and switchers were similar in rating how well-prepared they felt for college science and math courses, and persisters reported more than five additional hours per week spent on homework versus switchers. If not for one particular outlier, a member in the switcher group who self-reported a total of sixty hours per week (more than double any other student in that group), the persisters would have had an average time spent on homework more than double that of the switchers. While the switchers' answers reflect their study habits in their new majors, which have very different assignments than the exam and problem set-driven worlds generally encountered in introductory math and science courses (namely, switchers' majors require far more intensive writing assignments, which to an outside observers might seem less palatable to ELL students), the persisters' time dedicated to their work may reflect some of the differences of how they responded to difficult coursework.

As a whole, both groups were near the midpoint of the 1-4 scale for both math and science, with relatively few students indicating a feeling of very prepared or very unprepared, with slightly higher marks for science than for math. In discussing their experiences from open-ended questions, however, nearly all of the switchers and a majority of persisters mentioned feeling underprepared and/or overwhelmed at some point in their coursework, and this feeling lay at the root of most of the switching decisions among the ten switchers who would remain in four-year colleges. Difficulty with mathematics, and the jump in the skills demanded from the math offered at BELL to that which was required for their major in college, were concerns voiced with especially high frequency (but not among those who had been able to take a College Now math course), especially among switchers. To be sure, this was not surprising given that BELL's highest math course offered on site has generally been a course aimed at Algebra II

content without much daily homework and a pacing and focus that reflects the tenuous grasp of elementary algebra skills with which most of their classmates (and some of these students themselves) entered their senior year of high school. Other concerns that were voiced included a general sense of feeling overwhelmed at times by the more advanced academic and/or linguistic skills of their peers, by the far more rapid pacing of classes in college than at BELL, by the length and complexity of required readings, and by material in some science courses that was completely foreign to them.

It is instructive to take a deeper look at the challenges faced by the persisters in college and how they responded. Indeed, sixteen of the twenty-seven BELL STEM persisters considered switching out of STEM, or out of college altogether, and for thirteen of them this was due primarily to frustration and difficulties they faced in some of their classes, which were summarized above. There were also instances, six involving professors and five involving peers, where persisters reported perceptions or observations of inequitable treatment of themselves or their peers on the basis of their language skills, status as recent immigrants, or racial or ethnic identities, sometimes in classrooms and other times elsewhere on campus. Other students expressed sentiments that they felt that they and others were treated fairly and equitably around campus, frequently also including observations that many of their peers were from very homogeneous settings and simply had not previously interacted with immigrants, for example, or others who did not look like them.

In the U-State community, as would be discussed by BELL persisters as well as U-State non-BELL persisters, it was apparent that some members of the community on and near the campus had not been welcoming of a campus community that saw its number of students of color more than double over a five-year period, from a library coffee shop clerk accusing a

student of stealing a snack to employees of the local Wal Mart continuing an abhorrent tendency of watching and following Cameron and other students while they are shopping. U-State was also in the middle of a contentious situation around the time of my most recent visits in which two students had sent a series of three threats to a faculty member of color from the African American Studies department. Students and staff were openly discussing these threat notes with each other and with me, and I even received a text message from a concerned student late one evening following a student meeting on the matter. This situation was quite concerning, as were each of the incidents that students raised from within their classes, dorm halls, or elsewhere, but they were not among the factors students cited as the primary challenges they faced to persisting in pursuing their career goals. Indeed, at U-State in particular, the BELL students overall felt quite comfortable and open with expressing themselves, feeling a sense of camaraderie with the extended "BELL North" family and everyday climate they felt on the campus, with their peers, Ajit and his staff, D and his Center for Diversity, and others.

In terms of the persisters' classroom experiences, on the positive side, they mentioned enjoying a number of professors who connected course material to real-world experiences and using demonstrations and other effective visualization techniques (neither of which was commonly mentioned by switchers when asked about positive aspects of their college STEM classes before they switched). They also voiced concerns about many courses moving too fast, course grades focused solely or mostly on exam performance, and some professors "not going *into* the material more deeply" or "not going beyond" to engage the students, but only four reported the likes of a competitive "weed-out" culture wherein professors and/or the culture of their courses made it apparent that some students were simply not expected to make it.

Certainly, some STEM persisters are flourishing more than others – seven have a B+ average or higher (3.35-3.83), while at the other end two students are struggling to maintain C's – but as a group, all of these students are firmly committed to their goals and finding a way to reach them. Table 7.7 shows themes that emerged from conversations about how students responded when they felt unprepared or overwhelmed, while Table 7.8 lists the set of themes that reverberated throughout students' discussions of their "keys to persistence." Both of these tables center around the strong characteristics of resilience that these students demonstrated over time, many of them illustrated in some of the anecdotes shared earlier in this paper.

THE POWER OF RESILIENCE AND BUILDING UPON PRIOR STRENGTHS AND EXPERIENCES

First and foremost, these students believed strongly in their abilities to muster up whatever was needed at a given point in their path to reach their goals, they remained strongly attached to those goals. As Juana exclaimed, "When I'm ready to fly, I can't be held back." As expressed earlier and manifested again in students' discussion of their persistence, essential to many of their goals was a sense of social responsibility, a strong will to channel their accomplishments to give back to improve their communities, back home as well as here; this quality, in line with the traditional recent-immigrant sense of hope, reflects a manifestation of what researchers refer to as the optimal, healthiest adaptation or response to the negative social mirroring that they have been exposed to (and which many of them have ignored or barely noticed) in some of their experiences in New York City and on campus (Suarez-Orozco & Suarez-Orozco, 2001). This dual frame may also be behind the common refrain from students that this – the very subjects they were studying at the very college that had opened a window of opportunity for them – was the only place to be, the only thing to do.

Closely related to their internal locus of control, self-efficacy, and goal orientation is a growth mindset, a sense that one's intelligence is not fixed and that dedicating time and effort can result in significant cognitive gains. This quality and its relevance to motivation has been highlighted by Stanford psychologist Carol Dweck (Yeager & Dweck, 2012) and discussions and interventions related to it are utilized by some of the OP program directors during their pre-freshman summer programs to help get students off onto the right foot. Arianny, Sela, Mamady, Aissatou and a number of the other students who have been described previously may learn about the formalities of this concept from such discussions, but they have embodied it for years, even decades, of their lives.

Table 7.7
Responding to Feeling Unprepared: Common Themes

"Nowhere else to go"
Self-efficacy / strong belief in ability to overcome difficulties (academic or otherwise)
Growth mindset
Knowing and exploiting your resources
Focusing on strengths

Table 7.8
Internal Keys to Persistence: Themes from Self-Reflection

Strong sense of self-efficacy
Strong internal locus of control
Goal-orientation and focus
"No other options"
Social responsibility / obligation to give back
Adeptness at reaching out for help

Persisters were also keen on recognizing strengths and resources around them and becoming adept at using them. Internally, this included learning ways to teach themselves new

material and sift through challenging readings, skills they needed to survive in their college classes. This also included explicitly drawing on strengths and experiences from their past, part of what scholars of immigration refer to as the dual frame of reference that immigrants, especially those who spent most of their formative years in their home country, have at their disposal. Beyond their own experiences, this resourcefulness also meant being open to and assertive about reaching out for help when needed from a professor, advisor, friend, or high school mentor. While some switchers mentioned not keeping in touch with past mentors or having trouble finding help – and certainly, some campuses and programs facilitated student success more than others – persisters consistently discussed their willingness at reaching out and the benefits of doing so.

The persisters were not shy in pointing out specific reasons they belonged at their colleges. They also discussed the advantages that they believed their experiences at their colleges conferred upon them that would not have been available through the local community college options to which many admissions officers and senior administrators and executives would have confined them. Their comments extend from the key themes already elaborated in other responses they gave, as distilled in Tables 7.7 and 7.8, and which connect naturally to Benard's (1991) and McMillan and Reed's (1994) conceptions of resilience, the protective factors that students find from mentors, from their communities, and from within. They also lend themselves to the contemporary work of psychologist Angela Duckworth on "grit," a construct analogous to resilience, as discussed by Paul Tough in his attempt to hone in on non-cognitive factors that can contribute as much or more to long-term educational success than more traditional cognitive measures (2013). Tough elaborates on a dynamic combination of motivation and volition that can bring transformative results, and the words and actions of the

persisters in this study seem to drive these points home. Jhoan, a persister whose resolve would be tried on a regular basis at a technology-focused institution where he went at length to describe a frequently toxic environment (fortunately the only such instance encountered to such an extent throughout the study), remarked about his persistence and those who doubt him:

> *Do students with higher SAT scores than me become more successful in life? Do they all even appreciate going to college? Are they even making the world any better anyways? I thought the problem in the world was to stop poverty and make the world a better and equal place to live in, but if these opportunities are not given to the right people, then there is no change. I think researchers should look at students with determination who want more from life and are willing to go all the way for success. I think college should be for everyone who is willing to do the work and graduate. Even though I have a lower SAT score, I have the curiosity to always learn something new.*

While most persisters may not have expressed the collective will and numerous themes represented by the group in one such statement, they were united in their descriptions of the benefits that they felt they were reaping from their college experiences. They talked about the new inspirations and role models that they found, about the connections they made and socializing experiences that helped them learn to make such connections – overt social capital-building experiences – and about the opportunities and resources that they recognized on their campuses that they knew would not have been as plentiful as commuter students at a local community college. Being away from home was a welcome reprieve for some but a challenge in some ways for many (nearly all of the persisters were in colleges outside of New York City), and even as they kept their communities here and, often moreso, back home in mind, they found themselves immersed in residential campus communities where they could focus more on

moving toward their academic and career goals with fewer distractions and with a more certain direction. As some students remarked, their experiences on their campuses allowed them to see their lives as more than just a set routine of shuttling between classes, their family's apartment, and in all likelihood a job with relatively heavy hours, based on their own assumptions as well as their observations of friends and relatives back home, including some in their fourth or fifth year in community college.

A few students noted that classes would have been easier had they started at a local community college (knowing the local four-year colleges had rejected them and their BELL peers, so that was not an option), and that they could have stayed in their comfort zones with their mother's cooking or their friends in their co-ethnic enclaves who all spoke their native language. On the other hand, they recognized the benefits of growing more independent and even finding added motivation from learning to leave their comfort zone and find new strategies for acclimating to new environments (an area in which they had considerable practice from their experiences arriving in the US and coming to BELL). Tamana reflected on her at-times uncertain path – from growing up fast as her parents' de-facto translator starting the day of their original journey to the US to suddenly being in classes of twenty-five rather than 150-300 students – and continuing as she built up her confidence in the years that have followed, "The harder you push, the harder you go. It's like when babies start walking, they fall down and then they come and try again. If we don't push ourselves, we won't progress or get anywhere."

FINDING THE "RIGHT" HELP: INSTRUMENTAL SUPPORT STRUCTURES

Central to a number of students' descriptions of the benefits of their college experiences so far in moving them toward their STEM career goals was a sense of getting extensive help and support, but more specifically, the "right help" that they needed at a given point in time. Prior

research focused on improving persistence of traditionally underrepresented students in STEM isolated a number of support structures at the college level that seemed to strongly impact student success (Maton, Hrabowski, & Schmitt, 2000; Tsui et al, 2007). Students in this study were asked to rate the impact of each of these factors, from both their high school *and* college experience, in hopes of identifying what they had found to be especially helpful, as well as to look for patterns between persisters and switchers, and between BELL students and others. The results for BELL persisters and switchers are shown in Table 7.9. Only seven students from the U-State persister comparison group completed these ratings, so their averages were not included in the table, but the unique patterns that emerged from their responses against those of the BELL persisters will be mentioned, albeit with the underlying assertion that more comparison students are needed to further strengthen any tentative claims. All ten BELL STEM switchers who had remained in four-year colleges responded, but this is still a very small sample size for inferential statistical analysis, so while their group means and standard deviations are shown, rigorous statistical analysis will focus only on the persister group.

Table 7.9
Impact of HS and College Support Structures in Pursuit of College/Career Goals

	BELL STEM Persisters	BELL STEM Switchers
Pre-freshman OP summer bridge Program	5.2 ± 1.0	5.1 ± 0.8
Academic advising – HS	5.5 ± 0.8	5.2 ± 0.7
Academic advising – College	4.7 ± 0.9	4.8 ± 1.6
Career advising – HS	5.2 ± 0.9	4.4 ± 1.1
Career advising – College	4.4 ± 1.3	4.6 ± 1.4
Personal counseling – HS	5.1 ± 1.0	4.5 ± 1.4
Personal counseling – College	4.5 ± 1.8	4.3 ± 1.5
Peer tutoring (predominantly as tutor) – HS	5.5 ± 0.7	n/a (insufficient data)
Peer tutoring (as tutee/tutor) – College	5.0 ± 1.1	4.4 ± 1.6
Research experience – HS	5.3 ± 0.9 (among n = 11 participants)	n/a (insufficient data)
Mentors – from HS	5.6 ± 0.7	5.2 ± 0.7
Mentors – from College	5.0 ± 1.3 (not including 11 "n/a" responses)	4.8 ± 1.8
Financial aid package – College	5.2 ± 1.4	5.5 ± 1.2
Sense of learning community – HS	5.0 ± 1.1	4.9 ± 1.1
Sense of learning community – College	4.8 ± 1.5	5.0 ± 1.8
Study groups – HS	5.2 ± 1.0 (not including 13 "n/a" responses)	4.9 ± 1.2
Study groups – College	4.4 ± 1.5	4.9 ± 1.2

Note: From Likert scale items, rated 1-6.

One may notice in examining the figures in this table that the persisters and switchers, on average, both rated every support structure positively (based on 3.5 as the midpoint on a 1-6

Likert scale). It is not entirely clear whether this might be connected with the overall sense of optimism and positivity that was characteristic of this particularly resilient group of young adults (again, with a dual-reference frame) or some other factor, but they do seem to be aligned with the overall positive views in students' responses to open-ended questions. Their views also seem to validate the application of the STEM persistence frameworks (Drew et al, 2008; Graham et al, 2013) to this study, as well as the extension or ramping back of Tsui's (2007) set of key support structures and program characteristics beyond individual colleges' retention programs to earlier stages in students' careers, such as high school and the transition to college, such that more students can benefit.

In an attempt to compare the relative levels of impact that students associated with different advising and counseling experiences, an analysis of variance (ANOVA) was conducted with the STEM persisters' ratings of academic advising, career advising, and personal counseling at the college and high school levels, and mentors from high school, for a total of seven groups. (Mentors from college were not included because eleven students responded "n/a" to this item, reflecting that they did not feel they had a mentor in their college setting, and this large number of missing data points – I opted not to regard their responses as "1" ratings for this item – would have made comparisons difficult with ratings of this item.) A cursory look at the BELL STEM persisters data shows a trend in which their ratings for support structures from high school are a bit higher than those they found in college, and the statistical analysis would pinpoint which relationships, if any, were statistically significant. The ANOVA revealed that the students' ratings of these seven support structures to be statistically non-equivalent ($F = 4.598$, $p = 0.0002$), and Bonferroni post-tests revealed statistically significant relationships (at the $\alpha = 0.05$ level) between four of the twenty-one pairs of support structures.

The first two pairwise correlations pointed to the high impact of BELL STEM persisters' academic advising experiences from high school, which were rated as significantly more impactful than (a) career advising in college and (b) personal counseling in college. The other two pointed to the high impact of the persisters' high school mentoring experiences as significantly more impactful than these same two lower-rated advising or counseling experiences from college. The students' ratings of the advising and counseling they received from college were about a full point above the scale midpoint, showing the students still felt they were helpful, but academic advising and mentoring relationships from BELL were significantly greater. This supports the findings elaborated in the previous chapter of the constant underlying belief, inspiration, reassurance, motivation, push to "go beyond," and bridge-building to outside resources and programs that these relationships helped to sustain the students and their interests beyond their high school years, to the present.

Looking back across the entirety of Table 7.9, among BELL STEM persisters, the three highest-impact structures or experiences were from high school mentors, high school academic advising, and acting as a peer tutor in high school (the importance of which was also discussed separately above). These were followed closely by early exposure to laboratory research in high school (among those who participated), career advising in high school, generous financial aid packages in college, and pre-freshman OP summer bridge programs. College study groups and the previously mentioned career advising and personal counseling from college were the lowest rated. The relative positioning of the ratings was distinct for the BELL STEM persisters relative to the switchers or the U-State persisters. Financial aid packages were rated most impactful by the switchers, followed by high school academic advising and mentoring experiences and pre-freshman OP summer bridge, all of which were also highly regarded by the persisters, but the

switchers saw the least impact from personal counseling in college, career advising from high school, and the peer tutoring that was available to help them (as tutees) in college; these last two characteristics had been perceived more positively by the persisters.

Even greater variation was observed when looking at the admittedly limited data available for U-State persisters. Whereas BELL STEM persisters consistently rated each high school support structure a bit higher than the corresponding support structure in college, the reverse trend was observed among non-BELL U-State persisters. The U-State persisters rated support structures from high school lower than any group rated any other support structures, rating each as relatively unhelpful or low-impact, with mean scores uniformly in the 2-3 range, below the scale midpoint of 3.5, in a number of cases giving a rating of "n/a" because they felt that some structures, especially mentoring or career advising from high school, were absent from their high school experience entirely. Sense of learning community in college, financial aid package, academic advising in college, and pre-freshman OP summer bridge program were the structures they rated highest, at 5.0 or higher.

While limited in sample size, the deep contrast between the experiences of the U-State persisters and the BELL students, from this data to earlier discussions of differences in enrichment/outreach opportunities in high school, raises questions of whether alternative, novel opportunity structures were in place for BELL students than those in other contexts. The data available from this investigation certainly suggest high-impact relationships and experiences from the high school experience at BELL. Combined with these students' strong senses of hope and "grit," in line with Werner and Smith's (1989) and Benard's (1991) resilience models, and the remarkable impact of such resilience and holistic external supports (Gonzalez & Padilla, 1997; Morales, 2010), these experiences may well have helped to compensate – and then some –

for some of their "on-paper" characteristics. The final chapter reflects further on these ideas through the lens of the students' own perspectives in an attempt to offer final words and recommendations to various stakeholders in the STEM education community.

Chapter 8

BROADENING ACCESS AND OPPORTUNITIES, RETHINKING WHAT IT TAKES TO PERSIST: IMPLICATIONS AND CONCLUSION

This final chapter aims to continue the synthesis of the previous chapter in distilling the key findings of the study, and ultimately to draw out conclusions that may help to inform and extend the field of research and practice that is aimed at transforming the status quo vis-à-vis the varied paths toward success in STEM fields, especially among oft-marginalized students such as low-income English language learners. One will notice the brevity of the conclusions to be drawn, relative to the deeply descriptive style adopted to this point. These final sections were necessarily truncated so as to grant maximum impact to the results.

The aim of this project has been to explore the trajectories and break down the successes of students who had been all but written off by many for success in postsecondary success – let alone in pursuing STEM careers requiring a Bachelor's degree or higher – so as to share lessons as to how to broaden access and opportunity to pursuing STEM majors and help students to persist in pursuing these fields of study. A STEM persistence literature has emerged in recent years emphasizing the importance of sustaining student commitment and engagement through science peer learning communities and early exposure to research (Graham et al, 2013); however, prior research has not followed a group of students such as this in such a way as to be able to stake claims of students succeeding in STEM fields with traditional "on-paper" characteristics that fly so far in the face of the conventional wisdom that is accepted nearly across the board within higher education. Furthermore, prior research has not extended Graham's framework to high-needs public high school settings, just as Maton et al's (2000) and similar programs aimed at improving persistence in STEM have focused primarily at the college

level in contexts that exclude many students with STEM aspirations. A deep understanding of the context of the students' lives has been essential to the study, and as such, it is only fitting to use their insights and advice to younger students and to various constituents across the educational and STEM enterprises, from schools to researchers to policy, to guide the discussion of where to go from here. In so doing, one can hope to galvanize new conversations and movements around who can and should be considered a legitimate STEM contender, and how to help these students to capitalize and build upon their strengths to sustain them on the road to successfully meeting their long-term goals.

In addition to discussing their own "keys to persistence" in STEM, the BELL STEM persisters also obliged my request for them to share advice crystallized from their own experiences to help and inform others. Their advice to their younger peers, those still in high school, was concise and straightforward. First, find ways to take advanced, college-credit courses whenever possible. Second, find and keep mentors from school, in the form of counselor(s) and/or teacher(s), close at all times. Third, be active in pursuing interests in STEM prior to college, from internships to other activities, being sure to take advantage of all opportunities that may be presented or available. Each of these pieces of advice was connected with the others, of course, as counselors and other mentors could connect students to courses (and in some cases utilize student input to effect change around the courses offered) and other programs, and getting involved in a particular program or course could also result in the forging of a mentoring relationship. To provide further details as to the types of involvement that students felt had significant lasting impact, Table 8.1 breaks down the types of activities most frequently cited by students as having long-term impact, with the rightmost column showing which were most frequently the students' "top picks" for highest impact.

Table 8.1
Later Impact of STEM Enrichment/Outreach Experiences (Self-reported by students)

Name of activity	Frequency listed as having long-term impact (n)	Frequency listed among top 1-2 highest long-term impact experiences (n)
Any STEM-related internship (including research, clinical, Eng/Tech int., other)	17	13
—Paid HS summer research (ACS Project SEED, etc.)	9	7
College-level STEM courses	11	7
Project Lead the Way	8	4
STEM-related college visits	14	3
Science Club	7	3
STEM-related college advising conversations	9	2
Science Festival(s)	7	2

As foreshadowed in prior discussions, internship experiences, headlined by BELL's relatively extensive opportunities to engage students in paid summer research at area universities, were the most heavily cited experience, praised by students for exposing them to entirely new settings and resources, opening their eyes as to what was possible, inspiring them to see why fluency with mathematical and scientific problem-solving was so important in a hands-on setting, and helping to clarify or refine their future goals by showing them what their everyday lives could look like in the future as college students and scientists. College-level STEM courses, through dual-enrollment programs at the school (which were more open) as well as local colleges after school and on weekends (into which students had to be placed on the basis

on standardized tests) were also frequently listed, with these courses helping to better prepare them for the rigors of college, both helping them to gain concrete skills that were needed in college and preparing them for the expectations and culture of college classrooms. Project Lead the Way was not available to students from BELL's first two cohorts, but it was invaluable among members of the two most recent graduating cohorts. PLTW prepared students for college-level coursework at BELL and in college and provided a stepping-stone for engaging and building their interest through cohesive units of hands-on experiments with often cutting-edge equipment. Concurrently, PLTW was a crucial component to fostering learning communities of serious, like-minded students who wanted to give back to their communities through medicine and health care.

In line with the prior work of Musetti and Tolbert (2010), alongside the enriching academic offerings above, college access experiences (e.g. personalized STEM career and college planning and advising as well as targeted college visits where they toured STEM facilities and met students in majors to which they aspired) were also credited as helping to further clarify what their life in college would look like, helping them to see themselves in their future settings and think through what it would take to achieve their goals. For some, other activities such as belonging to clubs or attending science/STEM festivals to further explore career interests, further their skills, or learn about exciting new STEM discoveries were also mentioned as important experiences. In summary, they advocated strongly to other students to take advantage of these myriad activities which they had personally experienced as emphatic contributors toward cementing and sustaining their STEM interests.

A number of similar thoughts were reverberated when the STEM persisters were asked for advice to pass along to the teachers, school administrators, researchers, and others within the

educational community who wish to expand opportunities for success in STEM to more students like them, and others in settings where the schools themselves may be quite restricted in the material resources that they have available. Table 8.2 breaks down student feedback-driven recommendations to high school teachers, counselors, and administrators (and those who train them) to improve STEM learning opportunities and access to entry into STEM fields in college, while Table 8.3 offers recommendations to university faculty, administrators, and the higher education establishment more broadly to improve persistence in STEM majors.

Table 8.2

Recommendations for High-Poverty Urban High Schools (Teachers, Counselors, Administrators, and Teacher Educators)

Offer more advanced and college-level courses (dual-enrollment, AP, etc.) to help students to prepare for and acclimate to the level of expectations of first-year college classes
Expand laboratory experiences (more experiments, fully equipped laboratory spaces)
Maximize students' exposure to the "real world" of what college and various STEM careers involve
— Develop strategic partnerships (i.e. with community organizations, universities) to address and fund unmet needs driven by student and teacher feedback and that optimize students' future opportunities
Be available to students as a guide, advisor, and/or mentor figure
Provide individualized attention and multiple chances to engage in and explore science (in ways that value students' funds of knowledge)
Promote the development of peer-focused STEM learning communities/networks
Provide opportunities for peer co-teaching

Table 8.3
Recommendations for Higher Education

College science teaching

— More visualizations and demonstrations of concepts

— Emphasis of real-world applications (including in STEM majors' courses)

— Approachable faculty invested in "going beyond" in explaining complex material to students and demonstrating belief in all of their students' abilities to succeed in their major(s)

— Movement away from transmission-based models of instruction and assessment, toward implementation of broader assessment tools (and providing sufficient support to students for courses that remain exam-driven)

Campus climate and culture

— Alignment between admissions, Opportunity Programs, federal student success programs, diversity offices, and faculty around supporting students culturally, socially/emotionally, and academically

Macro-level

— Less reliance in Admissions (including Opportunity Programs and Multicultural Admissions) on raw SAT scores, more consideration of performance within high school and student context as well as non-cognitive factors

— Expansion of Opportunity Program funding: more seats, institutions, states

Students called on high schools to try to find ways to offer more advanced and college-credit courses so that students would be comfortable and ready to tackle the expectations and demands of freshman college classes, including the typical "gateway" courses needed for entering into most STEM fields. With these courses helping to prepare students for the rigor and habits of mind necessary to be primed for success, they also want to see schools developing laboratories, and using them frequently for students to do experiments, to engage students in a hands-on fashion to feel more engaged and inspired to "do" science. Their next suggestion

advocated for educators to mentor students, to build relationships with them to guide them, to advise them, and to just be there to talk with them, providing them with individualized attention, an ear to listen to their concerns and dreams, and multiple chances or opportunities to become the best that they can be. Finally, they circled back to the overarching theme of exposure, asking teachers, counselors, and administrators to help (and researchers to explore) ways to expose students to as much as possible within the realm of college and careers, connecting school to the real world and using it as a place of active exploration of students' futures.

Naturally, these recommendations are all easier said than done, and are reflective of these students' own experiences having successfully navigated their way through the unique environment of BELL and then college. They are, perhaps not surprisingly, deeply aligned with the strategies and approaches that I have been discussing throughout this paper, following his long-term engagement with BELL and the communities that comprise it. The students did not discuss the formalities of non-cognitive factors such as resilience, or the theoretical underpinnings of avoiding a deficit perspective and drawing from students' strengths and prior habitus and funds of knowledge in the continued cultivation of social and cultural capital that would help them to succeed; however, their collective experiences and explanations became a sort of living and breathing manifestation of these frameworks as they strived toward emancipatory change that would open more doors for those who would come after them.

My students – who came to be co-researchers at various points throughout the study – and I are clear in our resolve to blaze new trails and models for student success in places where so much of society still is not looking. We know collectively what seemed to work in the particular settings and spaces, and particular webs of relationships, in which they resided and which they helped to shape, and bring with them concrete suggestions that might be brought to

scale with great success in more schools, communities, and college settings. At the same time, because of this very contextualized and relationship-driven fabric, there is an understanding that simply advocating for or funding mentoring, STEM enrichment and outreach programs, and advanced courses will by no means guarantee the kind of implementation or successes – or challenges – that were observed here. Context and relationships are deeply nuanced by all of the constituents involved, from the dynamics and logistics of a given school to the unique strengths and challenges brought to the table by its students and staffs, to the resources and programs of the local and extended communities.

Certainly, further research is needed, from continuing to follow groups of students like these through college completion to larger-scale studies that may be able to establish causal links within and across a number of contextual settings. Clues drawn from this study, however, could be helpful here and now to individuals and groups looking to transform the opportunities available to students. They could be instrumental to building relationships over time inside and across schools and higher education and community-based organization (CBO) partners to leverage students' and other constituents' strengths to foster transformative symbiotic change in the very achievement ideologies and accompanying trajectories that will provide hope to engage so many youths and rock the foundations of expectations present across many of the nation's educational institutions and the policymakers that impact them.

There is no doubt that lessons and resources pulled from the specific context of this study can help to transform opportunity structures and trajectories of similar as well as quite different groups of young people who have been long marginalized by certain key decision-makers in society in general, and by the gatekeepers who restrict access to fulfilling STEM careers in particular. At a time when the federal government has called upon the nation and its schools to

find new ways to “engage and inspire” large numbers of students into STEM (PCAST, 2010), it would behoove educational practitioners across secondary and postsecondary institutions, community-based organizations, researchers, and policymakers to carefully study models such as this one to build their own robust, multi-faceted pipeline programs that look for and value talent in places where a faulty status quo has repeatedly struck out.

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Appendices

Appendix A

Phase i: Semi-Structured Focus Group Protocol

Developed by Jeremy Heyman and Christopher Emdin
Note: Some questions developed as the interview proceeded, from students' prior responses.

1. Can you describe any strong communities outside of school that help to sustain you?

2. What makes you a "science person," or a good science student?

3. Discuss your "journey" in science up to the present.

4. You're here in New York, but your reference point is "back home," in your native country. Hows does this idea of "back home" relate to what you have to do here in the US? Do your prior experiences motivate and empower you? What is the impact of "back home" on your intensity, focus, and work? To what extend does it matter? (And what do you think happens to people who don't have a "back home" to motivate them?)

5. So what is the difference here – what motivates *you* to translate your terrible prior experiences toward a drive to education? What is that "extra" thing, if there is one, for you? Is there, in fact, a "gift of poverty" or a "curse of luxury?"

6. What makes you do things differently than other students with similar frames of reference?

7. It seems that maybe there is a theme of going through something so challenging and not wanting to go back there. But what makes education that thing for you?

8. After completing your schooling, do you want to continue your life here, or go back to work in your home country one day?

9. Please give a brief conclusion of your thoughts from the ideas you each presented today.

10. Please discuss your early life experiences, and how they have shaped you.

11. Tell us about your immigration story – how did you end up here?

12. Do you ever have the opportunity to have this type of conversation?

13. Please talk about your experiences with science and math while growing up in your countries. What were classes like? Did you have any significant science and math experiences outside of classes in your country?

14. From what you're saying, it seems that it's about being around science and "doing" science. Could you speak to that?

15. Please talk about your role models in life. Who has been a significant influence in your lives?

16. Who and/or what has been significant in contributing to your career aspirations? Do you have a science "hero?"

17. Let's talk about this co-teaching thing. How do your see yourselves in that role as teachers?

18. What is that experience (learning from peer co-teachers) like for you?

19. Where do you see yourselves in the year 2022?

20. What drives your motivation in science?

21. Are you naturally drawn to science, like a magnet, or are you someone who had to be led to it?

22. Is your interest in science primarily based on (a) pure curiosity about the natural world, (b) liking to solve problems, or (c) an interest in real-world concerns?

23. Who do you represent?

24. How do we (researchers/educators), as teachers, get most of our students to go beyond the parts of science that just look cool, to put in the hard work, to understand the homework, the difficult parts of learning?

25. How prepared do/did you feel for college, coming out of Bell High School?

26. Evaluate the standards and expectations for students in math and science at ELLIS. Compare them with expectations you have observed in your country or in other places in New York? And compare them with the expectations that you think schools should have for all students.

27. What do you think the most important factors (a) inside and (b) outside of a person's control that will affect their success in college in general, and in science in particular? You can include as many as 5 factors from each category (internal and external).

28. How about neighborhood effects?

Appendix B

Phase i: Preliminary Background and STEM Experience Survey

I. General Information

1. Name _____

2. Preferred e-mail address: _____

3. Preferred phone number: _____

4. Gender _____

5. Race/Ethnicity *(underline one):* Hispanic Black White Asian Other:_____

6. Date of Birth (Month / Day / Year): _____ / ____ / _____

7. Year of High School Graduation: _____

8. Address (and city, state, and zip code) where you lived for the greatest length of time in the past 4 years:

Address: _____ City: _____ State: NY Zip:_____

9. City or town or village where you spent the greatest length of time from age 5 until 4 years ago:

City/Town: _____ State/Province: _____ Country: _____

II. High School Information

1. Name of school you attended prior to Bell HS: _____

2. Location (city/state/country) of school in #2: _____

3. Type of school in #2 (underline 1): Public Public Magnet Public Charter Private

4. Was the school in #2 free? _____

5. List math/science/medicine-related jobs, volunteer positions, internships, trips, clubs, shows, competitions, honors, fairs, and activities you experienced from age 14 onward:

_____

III. College Plans

1. List your top 2 majors you are thinking of pursuing:

I. _____ II. _____

2. List the top 2 (long-term) careers you are thinking of pursuing:

I. _____ II. _____

IV. Family Information

1. How many total siblings do you have (full, half, or step), with whom you have lived for at least 1 year of your life? __

2. How many of these siblings are older than you? __

3. Your biological (or adopted) parents are *(underline one):* Married Separated Divorced Other:_____

4. Who did you live with (who "took care of you") for the largest amount of time from your birth until 2009?

(Underline all that apply.)	Mother	Father	Step-Mother	Step-Father
	Aunt	Uncle	Grandmother	Grandfather
	Other Adult Relative		Adult Non-Relative	No Adults

5. Who did you live with for the largest amount of time from 2009 until you started college?

(Underline all that apply.)	Mother	Father	Step-Mother	Step-Father
	Aunt	Uncle	Grandmother	Grandfather
	Other Adult Relative		Adult Non-Relative	No Adults

V. Family Education Background

1. Which is the highest level of education completed by your biological (or adopted) father?

2. Which is the highest level of education completed by your biological (or adopted) mother?

VI. High School Experience

1. How has your level of interest in a STEM field(s) changed from 2008 to present?

_Decreased Significantly _No change _Increased Significantly
_Decreased Slightly _Increased Slightly

2. How prepared to you feel for the college-level work you will need to take (to pursue your STEM goal) in science?

_Very unprepared _Somewhat prepared
_Somewhat unprepared _Very prepared

3. How prepared do you feel for the college-level work you will need to take (to pursue your STEM goal) in math?

_Very unprepared _Somewhat prepared
_Somewhat unprepared _Very prepared

4. What do you expect to be your largest challenge in pursuing your STEM goal in college?

_____

VII. Personal Interests and Tendencies

1. At what age did you decide that you wanted to pursue a career in a STEM area? _____

2. Did you love science from a young age (by age 10)? _____
Did you love math from a young age (by age 10)? _____

3. List your top 3 hobbies when you were a child 6-10 years old.

_____

4. What is it that made you want to enter the STEM-related career that you mentioned earlier?

_____

5. Would you classify yourself more as (a) someone who is naturally drawn to science and/or math or (b) someone who needs to be led to an interest in science and/or math? ___

6. Describe any influence(s) that other students, teachers, other school staff, supervisors, family members, or other individuals have had on your interests in a STEM-related career.

_____

7. What do you predict to be your largest challenge in reaching your STEM-related career goal?

_____

8. Have you ever participated in a laboratory research, hospital, or science museum-related job, internship, volunteering, or other STEM-related program outside of school? If so, please list each position you held, the name of the organization, and the year(s).

_____

9. How, if at all, have the experiences in #8 affected your career goals?

_____

10. On a scale of 0-3, how important are each of the following factors to you in your interest in pursuing a STEM-related career? (0=not important; 1=a little important; 2=quite important; 3=supremely important)

a. Curiosity to learn and discover new things about the world	**0 1 2 3**
b. Potential for helping people	**0 1 2 3**
c. Job security and job prospects	**0 1 2 3**
d. Salary	**0 1 2 3**
e. Enjoyment of doing math and/or science	**0 1 2 3**
f. Having meaningful relationships with professors and peers in the field	**0 1 2 3**

11. How would you rate yourself in the following areas? (0=poor; 1=OK; 2=good; 3=excellent)

a. Competence in pre-requisite understanding/knowledge in your desired field	**0 1 2 3**
b. Confidence in your understanding of your field	**0 1 2 3**
c. Persistence	**0 1 2 3**
d. Assertiveness	**0 1 2 3**
e. Resourcefulness	**0 1 2 3**

Appendix C

Phase i: Follow-Up Questionnaire

1. Now that you have more experience as a college student, what do you think you got from your time at ELLIS that you might not have gotten elsewhere, at other schools?

2. How well-prepared do you feel that you were for college, *based on what you experienced this past year*? Describe anything that you feel you MISSED at ELLIS that you might have gotten elsewhere.

2. Describe your "journey in science" (and/or as a science student) over the past year.

3. What has made you successful in college science and math courses? What has challenged you in these classes?

4. (As of today,) What do you think you will be doing 5 years from now?
And are there any changes since last year about what or who has been important in driving your career aspirations?

5. What's it been like for you so far as a science student in college?

6. Can you compare math and science at ELLIS to math and science in college?

7. At this point in your education:
What factors or aspects INSIDE of a person's control are most important for success as a science major in college?
What factors or aspects OUTSIDE of a person's control are most important for success as a science major in college?

8. Who are your key *allies* as a successful college student?

Appendix D

Phase i: Final Pilot Questionnaire

1. As of today, what is your current major, and your career goal? (If you have more than one major and multiple career goals, please include all of them.)

2. How have your friends and classmates impacted your academic performance and your career-related decisions? (Include any clubs or other extracurricular activities on campus that have been important to you.)

3. How has interaction with your university professors impacted your academic performance and your career-related decisions? Do you feel that you have a strong relationship with any professors? If so, please describe.

4. How have interactions with academic advisers and other university advisers impacted your academic performance and your career-related decisions?

5. Have there been any moments since your arrival in college when you considered leaving the sciences? If so, please describe what happened, and how you responded. What supports or factors were most important in making your decision to stay in your major (or to switch majors)?

6. From the day you started college until today, what have been the biggest challenges to success in your original major/career plan?

7. Which class or classes have been the most difficult for you so far in college? Why was it so difficult? What did you do to try to overcome the difficulty?

8. Many traditional college admissions people and scientists might look at the high school you attended, and the SAT Math score you received, and count you "out" as a person who can succeed in your field and make significant professional contributions to society. If you had up to 100 words to respond to such people, how would you respond?

9. Feel free to write any other comments or ideas that you would like to share about your experiences.

Appendix E

Phase ii: Preliminary College STEM Success Questionnaire

The first set of questions refers to your FINAL 2 YEARS IN HIGH SCHOOL.

1. How frequently did you tutor another student in science or math, or serve as a teaching assistant in a class?

- 2-5 times per week
- 1 time per week
- a few times per semester
- never

2. How often did you study math or science with other students?

- 2-5 times per week
- 1 time per week
- a few times per semester
- never

3. How often were you a guest in a teacher or other school staff member's home (before college)?

- 3 times or more
- 2 times
- Once
- Never

4. How frequently did you ask a teacher or counselor for advice outside of class?

- 1 or more times per week
- About 1-2 times per month
- About 1-3 times per year
- Never

5. How frequently did you look up scientific research articles?

- More than 5 times
- 3-5 times
- 1-2 times
- Never

6. How frequently did you read science-related books (not including a textbook for a class) or magazines?

- More than 5 times
- 3-5 times
- 1-2 times
- Never

7. How many times did you visit a science museum, science fair/festival, or other science site as part of a school trip?

- More than 2 times
- 1-2 times

- Never

8. Who were the 2-3 people with whom you mostly discussed your future plans? *
- Parent(s) and/or grandparent(s)
- Science teacher
- Math teacher
- Other teacher
- Counselor
- Friends from ELLIS
- Friends not from ELLIS
- Brothers, sisters, or cousins
- Other: _____

9. How many hours did you spend in an average week doing homework/studying for science courses?
- 6 or more
- 4-5
- 2-3
- 0-1

10. How many hours did you spend in an average week doing homework/studying for math courses?
- 6 or more
- 4-5
- 2-3
- 0-1

11. How many hours did you spend in an average week doing homework/studying for OTHER courses?
- 6 or more
- 4-5
- 2-3
- 0-1

12. How many hours did you spend in an average week staying after school to work on science/math homework, projects, and studying?
- 6 or more
- 4-5
- 2-3
- 0-1
- Other: _____

13. With whom did you most frequently work on your science/math homework and other science/math learning that you did? (Check one or more.)
- Science teacher
- Math teacher

- Classmates
- Family members
- I mostly worked alone

14. How many scientists, engineers, doctors, or other STEM professionals did you meet or speak with?

- 3 or more
- 2
- 1
- None

15. Do you feel that you had any science/STEM mentor(s) helping to guide you toward success in college and beyond? Please describe how many of these people you had and what level and kind of impact they had (and if it was mostly in high school or if it has continued).

16. In which of the following did you participate? Check of as many as you participated in.

- ACS Project SEED
- Project Lead the Way
- STEP or SPREP Saturday program
- College visits where you toured labs and/or met science students or professors
- College Now math or science course
- Local science festival or fair
- USA Science and Engineering Festival
- Science Club or Science Research Discussion Group
- College counseling conversations related to science, medicine, or engineering programs
- Volunteering or working at a hospital or clinic
- In-person or Skype meetings with scientists or other STEM professionals
- Writing a science research paper about an issue of concern to you
- Producing a video, song, or other creative science project about an issue or concept of interest to you
- Speaking with BELL alumni in college with a STEM major
- Competitions (in or outside of class)
- Recruit other students to join a STEM-related program
- Other STEM-related internship experience
- Other STEM-related leadership experience

17. Which of these programs (from #16) do you think has positively impacted you beyond high school?

18. Which 1-2 of these programs (from #16), if any, do you think were especially impactful and important for your future? Please explain.

This next set of questions is more about your transition to college, and your experiences in college.

19. How did you learn about and decide on your current major, and the kind of courses and future work that it involves?

19a. Which of the following significantly impacted your decision in choosing (and keeping) your major?

- High school teacher(s)
- High school counselor(s)
- HEOP/EOP advisor
- Academic/major advisor (in college)
- College science professor(s)
- College math professor(s)
- CSTEP advisor
- College friends
- High school friends
- Internship supervisor
- Family member(s)
- Other: _____

20. Have there been times in your college experience that you have felt under-prepared for the academic content or skills of any of your science or math courses? Please describe.

21. What helped you to respond to these challenges and to be successful in these courses at the college level?

22. Please describe any experiences or relationships that have helped you to be successful in your major (and perhaps moreso than some of your peers)?

23. How frequently do you speak with science or math teachers/mentors from high school (beyond just saying "hi")?

- At least once per month
- A few times per year
- About once per year
- Never

24. How frequently do you speak with friends from high school (beyond just saying "hi")?

- At least once per week
- 1-2 times per month
- a few times per year
- about once per year
- never

25. Were there aspects of teaching methods or assignments/exams or class grading in some STEM classes that made learning harder? Please describe them, and how you overcame the challenges.

26. As you may have found, your high school did not offer some of the courses that many of your peers had access to in high school. What do you think has helped you to be successful in spite of these unequal opportunities?

27. Were there times when you seriously considered leaving a STEM-related major, or leaving college completely? How frequently did this happen?

- 3 or more instances
- 2 instances
- once
- never

28. What are your "keys" (influences, relationships, perspectives, strategies, etc.) to PERSISTING in your major?

29. Which of the following are key sources of support to you in college?

- First-Year Experience programs connecting you to students with similar interests
- HEOP/EOP or TYP
- college professors
- college advisors
- college internship internship or job experience
- on-campus club related to your career interests
- CSTEP
- college friends/roommates
- family members

30. Who are your 1-3 key role models or mentors or advisors, as related to your major or career goals? How did you meet these people? How do they help you?

These last questions are about reflecting back on your experiences over the past several years.

31. Many leading colleges and scientists might have looked at your SAT scores or high school transcript and rejected you and your aspirations. Researchers studying students persisting or leaving science tend to focus on students with SAT scores at least 300-400 points higher than yours. How would you respond to such people to explain your successes?

32. If you were advising students a few years younger than you, what are the 2 most important things that they can do before starting college to prepare themselves to succeed in college science/math?

33. If you were advising high school principals (or teachers and counselors), what are the 3 most important things their schools need to do (being mindful of limited resources) to help prepare students for success in college science/math?

34. If you were giving advice to people who work (as teachers, college professors, advisors, coordinators, etc.) or do research in helping students to succeed in college STEM majors when their high schools and communities had limited financial resources, what advice would you give them to help more students to succeed?

Appendix F

Phase ii: Semi-Structured Interview Protocol (BELL)

I. General Information

1. Name _____

2. Preferred e-mail address: _____

3. Country of birth: _____

4. Country(ies) of parents' birth: _____

5. Date of Birth (Month / Day / Year): _____ / ____ / _____

6. When did you arrive in the US? _____

7. Year of High School Graduation: _____

8. Address (and city, state, and zip code) where you lived for the greatest length of time during the 3 years prior to college:

Address: _____ City: _____ State: NY Zip:_____

9. City or town or village where you spent the greatest length of time from age 5 until 3 years prior to college:

City/Town: _____ State/Province: _____ Country: _____

Setting (circle): Rural Urban Suburban Small City

10. Languages learned before English: _____

II. School Information

1. Name of school you attended prior to BELL HS: _____

2. Location (city/state/country) of school in #2: _____

3. Type of school in #2 (underline 1): Public Public Magnet Public Charter Private

4. Was the school in #2 free? _____ If not, how much did it cost per year? _____

4a. Describe the length of the school day (and any outages/strikes) in your schools prior to BELL.

_____

5. Do I have your permission to see and utilize your HS transcript for this project?

6. Do I have your permission to see and utilize your SAT/ACT scores for this project?

7. Do I have your permission to see and utilize your college transcript for this project? Can you share an unofficial copy with me?

III. Career Plans

1. List your major(s) or proposed major(s)

I. _____ II. _____

2. List the top 2 (long-term) careers you are thinking of pursuing:

I. _____ II. _____

3. List math/science/medicine-related jobs, volunteer positions, internships, trips, clubs, shows, competitions, honors, fairs, and activities you experienced from age 14 until your enrollment at BELL:

_____

4. List math/science/medicine-related jobs, volunteer positions, internships, trips, clubs, shows, competitions, honors, fairs, and activities you experienced since graduating from BELL:
_____

IV. Family Information

1. Your biological (or adopted) parents are *(underline one):*

Married Separated Divorced Other:_____

2. Who did you live with (who "took care of you") for the largest amount of time from your birth until you arrived in the US?

3. Who did you live with for the largest amount of time from the time you arrived in the US until you started college?

4. What is your best estimate of your family income for the previous year? And how many people are in your household?

V. Family Education Background

1. Which is the highest level of education completed by, and current occupation of, your biological (or adopted) father?

2. Which is the highest level of education completed by, and current occupation of, your biological (or adopted) mother?

3. (If you have older siblings,) What is the highest level of education completed by an older sibling?

VI. High School Experience

1. How has your level of interest in a STEM field(s) changed from 10th grade to present?

_Decreased Significantly _No change _Increased Significantly
_Decreased Slightly _Increased Slightly

2. How prepared do you feel you were for college-level science coursework from your high school experience?

_Very unprepared _Somewhat prepared
_Somewhat unprepared _Very prepared

3. How prepared do you feel you were for college-level math coursework from your high school experience?

_Very unprepared _Somewhat prepared
_Somewhat unprepared _Very prepared

VII. Personal Interests and Tendencies

1. At what age did you decide that you wanted to pursue a career in a STEM area? _____

2. Did you love science from a young age (by age 10)? _____
Did you love math from a young age (by age 10)? _____

3. List your top 3 hobbies when you were a child 6-10 years old.
4. What is it that made you want to enter the STEM-related career that you mentioned earlier?

5. Would you classify yourself more as (a) someone who is naturally drawn to science and/or math or (b) someone who needs to be led to an interest in science and/or math? ___

6. On a scale of 0-3, how important are each of the following factors to you in your interest in pursuing a STEM-related career? (0=not important; 1=a little important; 2=quite important; 3=extremely important)

a. Curiosity to learn and discover new things about the world	**0 1 2 3**
b. Potential for helping people	**0 1 2 3**
c. Job security and job prospects	**0 1 2 3**
d. Salary	**0 1 2 3**
e. Enjoyment of doing math and/or science	**0 1 2 3**
f. Having meaningful relationships with professors and peers in the field	**0 1 2 3**

VIII. College STEM Experience Questions. Some of these items are connected with things you wrote about in the introductory questionnaire/survey a few months ago, but some things may have changed, and you can also provide more depth here in this interview.

1. Think of your four closest friends. What are they doing now, and where (studying, work)? If in college, what are they studying?

2. How many semesters of college have you completed so far? ____
2a. What is your expected graduation date? _____
2b. How much have you contributed to your college education (tuition, fees, room, board, books), not including work study? ____
2c. Do you have a work study job on campus? How many hours per week, for how long have you had it, and what do you do? _____

3. On average, how much time per week do you spend studying and doing homework? _____
a. in study groups? ____

4. What drew you into the sciences? Your major?
4a. How did you learn about what the major involved?
4b. How did you learn about what your future desired career involves?

5. Were there any ways that you felt underprepared during your first science and math courses in college? (Differences in workload, expectations, peers, language, text? Amount covered in class? Pacing? Study skills? Courses not available in HS? Difficulties with understanding material or completing the work? What caused the MOST difficulty?)
5a. What did you do to get past it? How did you figure out what to do?

6. Were there particular teaching methods, approaches, or activities in your STEM classes that helped your learning and motivation in college?

6a. What about research experiences or other internships before or during college?

7. Was there a "weed-out" system in some of your classes? (Explain term as needed.) Which courses? What made this class feel like a "weed-out" class? Did the grading or other aspects of the class create any problems for you? How did you progress or deal with it?
7a. Are STEM classes just difficult or do people (who?) make them harder than they have to be? Explain.

8. Have you ever thought of leaving STEM?
8a. When? What brought that about? Why?
8b. How did you respond? Did you discuss with anyone?
8c. Any "fork in the road" stories?

9. Let's talk a little about "official" or formal sources of help and advice. Professors, TAs, advisors, special program advisors/directors/counselors (H/EOP, CSTEP), tutors.
9a. How helpful did you find these sources?
How did you navigate or know how to navigate these sources?
Were there times you can describe when you need some sort of help but didn't get what you needed?
Were there times you hesitated from seeking support?
9b. With which of these do you feel you've built close, helpful relationships?
How often do you speak with them for help?

10. What about informal or unofficial sources of support? (Also see prompts from 9a and 9b.)
First, peers, family members, clubs and extracurricular activities, hallmates, family?
Second, research labs or internships or shadowships, friends you met from OP/access programs?
Third, people from before college.
10a. What has made you feel like you belonged (at this college, and in this major)?
How/where do you find your career-related role models?

11. Thinking back to numbers 8-10, have you ever thought about what your experience may have been like in STEM at other colleges? Like at community colleges back in your home city?

12. Low-income students, women, and students of color have long been underrepresented in most STEM fields. What are your thoughts about this?
Who and what has helped you in dealing with these issues?
Were there any ways people who taught or worked with you behaved that helped or hindered your sense of belonging in your major?
Were there elements of your experience that you think were different from those of other classmates?

13. Can you rate the importance of each of these at the high school and college level as a contributor to your current academic success in STEM?

(0 = very unimportant, 1 = unimportant, 2 = slightly unimportant,
3 = slightly important, 4 = important, 5 = very important)

	High School	**College**
a. Summer bridge	n/a	_____
b. Personal counseling	_____	_____
c. Academic advising	_____	_____
d. Career counseling	_____	_____
e. Peer tutoring	_____	_____
f. Professional tutoring	_____	_____
g. Research experience	_____	_____
h. Mentors	_____	_____

i. Financial support	_____	_____
j. Sense of learning community	_____	_____
k. Study groups	_____	_____

14. Can you rate the importance of each of these at the high school level (that you participated in) as a contributor to your current academic success in STEM?

a. ACS Project SEED / other research experience
b. Project Lead the Way
c. STEP or SPREP Saturday program
d. College visits where you toured labs and/or met science students or professors
e. College Now math or science course
f. In-school SUPA/AP college science course
g. Local/regional science festival or fair
h. USA Science and Engineering Festival
i. Science Club or Science Research Discussion Group
j. College counseling conversations related to science, medicine, or engineering programs
k. Volunteering or working at a hospital or clinic
l. In-person or Skype meetings with scientists or other STEM professionals
m. Writing a science research paper about an issue of concern to you
n. Producing a video, song, or other creative science project about an issue or concept of interest to you
o. Other project or work for a class
p. Speaking with BELL alumni in college with a STEM major
q. Competitions (in or outside of class)
r. Recruit other students to join a STEM-related program
s. Other STEM-related internship experience
t. Other STEM-related leadership experience

15. Which 1-2 of these programs (from #14), if any, do you think were especially impactful and important for your future in STEM? Please explain.

Also discuss any questions that were unanswered or partially answered from Appendix E questionnaire, or that the student wants to discuss.

Appendix G

Phase iii: Semi-Structured Interview Protocol (U-State)

I. General Information

1. Name _____

2. Preferred e-mail address: _____

3. Country of birth: _____

4. Country(ies) of parents' birth: _____

5. Date of Birth (Month / Day / Year): _____ / ____ / _____

6. When did you arrive in the US? _____

7. Year of High School Graduation: _____

8. Address (and city, state, and zip code) where you lived for the greatest length of time during the 3 years prior to college:

Address: _____ City: _____ State: NY Zip:_____

9. City or town or village where you spent the greatest length of time from age 5 until 3 years prior to college:

City/Town: _____ State/Province: _____ Country: _____

Setting (circle): Rural Urban Suburban Small City

10. Languages learned before English: _____

II. School Information

1. Name, location of HS you attended for grades 10-12: _____

2. Name, location of schools you attended prior to grades 10-12 (or 9-12): _____

3. Type of school in #3 (underline 1): Public Public Magnet Public Charter Private

4. Was the school in #3 free? _____ If not, how much did it cost per year? _____

4a. Describe the length of the school day (and any outages/strikes) in your schools prior to US arrival.

_____

5. Do I have your permission to see and utilize your HS transcript for this project? (If not, then ask about highest science and math courses taken, overall GPA, science and math grades, and Regents scores.)

6. Do I have your permission to see and utilize your SAT/ACT scores for this project?

7. Do I have your permission to see and utilize your college transcript for this project? Can you share an unofficial copy with me?

III. Career Plans

1. List your major(s) or proposed major(s)

I. _____ II. _____

2. List the top 2 (long-term) careers you are thinking of pursuing:

I. _____ II. _____

3. List math/science/medicine-related jobs, volunteer positions, internships, trips, clubs, shows, competitions, honors, fairs, and activities you experienced from age 14 until your enrollment in college:
_____

4. List math/science/medicine-related jobs, volunteer positions, internships, trips, clubs, shows, competitions, honors, fairs, and activities you experienced since graduating from HS:
_____

IV. Family Information

1. Your biological (or adopted) parents are *(underline one):*

Married Separated Divorced Other:_____

2. Who did you live with (who "took care of you") for the largest amount of time from your birth until you arrived in the US?

3. Who did you live with for the largest amount of time from the time you arrived in the US until you started college?

4. What is your best estimate of your family income for the previous year? And how many people are in your household?

V. Family Education Background

1. Which is the highest level of education completed by, and current occupation of, your biological (or adopted) father?

2. Which is the highest level of education completed by, and current occupation of, your biological (or adopted) mother?

3. (If you have older siblings,) What is the highest level of education completed by an older sibling?

VI. High School Experience

1. How has your level of interest in a STEM field(s) changed from 10th grade to present?

_Decreased Significantly _No change _Increased Significantly
_Decreased Slightly _Increased Slightly

2. How prepared do you feel you were for college-level science coursework from your high school experience?

_Very unprepared _Somewhat prepared
_Somewhat unprepared _Very prepared

3. How prepared do you feel you were for college-level math coursework from your high school experience?

_Very unprepared _Somewhat prepared
_Somewhat unprepared _Very prepared

VII. Personal Interests and Tendencies

1. At what age did you decide that you wanted to pursue a career in a STEM area? _____

2. Did you love science from a young age (by age 10)? _____
Did you love math from a young age (by age 10)? _____

3. List your top 3 hobbies when you were a child 6-10 years old.
4. What is it that made you want to enter the STEM-related career that you mentioned earlier?

5. Would you classify yourself more as (a) someone who is naturally drawn to science and/or math or (b) someone who needs to be led to an interest in science and/or math? ___

6. On a scale of 0-3, how important are each of the following factors to you in your interest in pursuing a STEM-related career? (0=not important; 1=a little important; 2=quite important; 3=extremely important)

a. Curiosity to learn and discover new things about the world	**0 1 2 3**
b. Potential for helping people	**0 1 2 3**
c. Job security and job prospects	**0 1 2 3**
d. Salary	**0 1 2 3**
e. Enjoyment of doing math and/or science	**0 1 2 3**
f. Having meaningful relationships with professors and peers in the field	**0 1 2 3**

VIII. College STEM Experience Questions. Some of these items are connected with things you wrote about in the introductory questionnaire/survey a few months ago, but some things may have changed, and you can also provide more depth here in this interview.

1. Think of your four closest friends. What are they doing now, and where (studying, work)? If in college, what are they studying?

2. How many semesters of college have you completed so far? ____
2a. What is your expected graduation date? _____
2b. How much have you taken out in loans so far to help meet tuition, fees, room, board, and book expenses? (If you get money back, subtract this amount.) _____
2c. How much have your parents contributed to your college education (tuition, fees, room, board, books)? ___
2d. How much have you contributed to your college education (tuition, fees, room, board, books), not including work study? ____
2e. Do you have a work study job on campus? How many hours per week, for how long have you had it, and what do you do? _____

3. On average, how much time per week do you spend studying and doing homework? _____
a. in study groups? ____

4. What drew you into the sciences? Your major?
4a. How did you learn about what the major involved?
4b. How did you learn about what your future desired career involves?

5. Were there any ways that you felt underprepared during your first science and math courses in college? (Differences in workload, expectations, peers, language, text? Amount covered in class? Pacing? Study

skills? Courses not available in HS? Difficulties with understanding material or completing the work? What caused the MOST difficulty?)
5a. What did you do to get past it? How did you figure out what to do?

6. Were there particular teaching methods, approaches, or activities in your STEM classes that helped your learning and motivation in college?
6a. What about research experiences or other internships before or during college?

7. Was there a "weed-out" system in some of your classes? (Explain term as needed.) Which courses? What made this class feel like a "weed-out" class? Did the grading or other aspects of the class create any problems for you? How did you progress or deal with it?
7a. Are STEM classes just difficult or do people (who?) make them harder than they have to be? Explain.

8. Have you ever thought of leaving STEM? (***Expand upon these items and alter 9 through end as needed for STEM switchers.***)
8a. When? What brought that about? Why?
8b. How did you respond? Did you discuss with anyone?
8c. Any "fork in the road" stories?

9. Let's talk a little about "official" or formal sources of help and advice. Professors, TAs, advisors, special program advisors/directors/counselors (H/EOP, CSTEP), tutors.
9a. How helpful did you find these sources?
How did you navigate or know how to navigate these sources?
Were there times you can describe when you need some sort of help but didn't get what you needed?
Were there times you hesitated from seeking support?
9b. With which of these do you feel you've built close, helpful relationships?
How often do you speak with them for help?

10. What about informal or unofficial sources of support? (Also see prompts from 9a and 9b.)
First, peers, family members, clubs and extracurricular activities, hallmates, family?
Second, research labs or internships or shadowships, friends you met from OP/access programs?
Third, people from before college.
10a. What has made you feel like you belonged (at this college, and in this major)?
How/where do you find your career-related role models?

11. Thinking back to numbers 8-10, have you ever thought about what your experience may have been like in STEM at other colleges? Like at community colleges back in your home city?

12. Low-income students, women, and students of color have long been underrepresented in most STEM fields. What are your thoughts about this?
Who and what has helped you in dealing with these issues?
Were there any ways people who taught or worked with you behaved that helped or hindered your sense of belonging in your major?
Were there elements of your experience that you think were different from those of other classmates?

13. Can you rate the importance of each of these at the high school and college level as a contributor to your current academic success in STEM?
(0 = very unimportant, 1 = unimportant, 2 = slightly unimportant,
3 = slightly important, 4 = important, 5 = very important)

	High School	**College**
a. Summer bridge	n/a	_____

b. Personal counseling	_____	_____
c. Academic advising	_____	_____
d. Career counseling	_____	_____
e. Peer tutoring	_____	_____
f. Professional tutoring	_____	_____
g. Research experience	_____	_____
h. Mentors	_____	_____
i. Financial support	_____	_____
j. Sense of learning community	_____	_____
k. Study groups	_____	_____

13. How much of a loan burden do you have each year? How much of a loan burden do you expect to have when you graduate? Have your parents contributed significantly to your college expenses?

14. Can you rate the importance of each of these at the high school level (that you participated in) as a contributor to your current academic success in STEM? *(Include similar programs.)*

a. ACS Project SEED / other research experience
b. Project Lead the Way
c. STEP or SPREP Saturday program
d. College visits where you toured labs and/or met science students or professors
e. College Now math or science course
f. In-school SUPA/AP college science course
g. Local/regional science festival or fair
h. USA Science and Engineering Festival
i. Science Club or Science Research Discussion Group
j. College counseling conversations related to science, medicine, or engineering programs
k. Volunteering or working at a hospital or clinic
l. In-person or Skype meetings with scientists or other STEM professionals
m. Writing a science research paper about an issue of concern to you
n. Producing a video, song, or other creative science project about an issue or concept of interest to you
o. Other project or work for a class
p. Speaking with BELL alumni in college with a STEM major
q. Competitions (in or outside of class)
r. Recruit other students to join a STEM-related program
s. Other STEM-related internship experience
t. Other STEM-related leadership experience

15. Which 1-2 of these programs (from #14), if any, do you think were especially impactful and important for your future in STEM? Please explain.

16. Please discuss your college application process, which colleges were your top choices, and how you decided to attend this college. Also explain how you came up with your college list, who helped you through the process, etc.

Also discuss any questions whose themes have not yet been discussed from Appendix E questionnaire.

Appendix H

Selected Summary Characteristics of BELL STEM Persisters

	Name (Pseudonym)	Age at arrival in US	Home country	Gender	SAT Math	HS GPA	SIFE (or inconsistent full-time schooling)	College major
1	Mamady	20	Guinea	M	510	95	Y	Pharmacology
2	Aissatou	18	Senegal	F	440	92	Y	Nursing (BSN)
3	Sela	18	Togo	F	500	95	N	Biochemistry/ Pre-med
4	Tamana	19	Bangladesh	F	470	94	Y	Civil engineering
5	Ignacio	17	DR	M	470	88	N	Computer engineering
6	Rahman	16	Bangladesh	M	450	94	Y	Computer engineering
7	Abou	15	Cote D'Ivoire	M	440	94	Y	Mechanical engineering
8	Khadija	15	Togo	F	480	97	N	Mathematics / Pre-med
9	Ramon	15	DR	M	500	85	Y	Mathematics / Math education
10	Fati	17	Togo	F	470	95	N	Biology/Pre-health
11	Juana	17	DR	F	320	91	Y	Biology/Pre-dental
12	Maria	17	DR	F	400	91	Y	Biology
13	Arianny	15	DR	F	240	93	Y	Health Sciences/ Physical Therapy
14	Jhoan	17	DR	M	440	88	N	Electrical engineering technology
15	Deepak	17	Nepal	M	560	85	Y	Information technology
16	JAM	18	Nicaragua	M	410	80	Y	Information technology
17	Cameron	16	Colombia	F	350	86	Y	Public health
18	Mario	17	DR	M	410	85	Y	Architectural technology
19	Ngoc	19	Vietnam	F	700	93	N	Chemistry
20	Lisa	16	Ecuador	F	440	93	N	Biology/Pre-health
21	Mariam	16	Guinea	F	350	94	N	Nursing (BSN)
22	Yahaira	18	DR	F	330	89	Y	Undecided Health
23	Bryan	15	DR	M	370	76	Y	Information technology
24	Sekou	17	Guinea	M	450	86	N	Public health/ Health sciences
25	Marlin	17	DR	F	330	91	Y	Public health/ Pre-Health
26	Kamel	16	Togo	M	350	87	N	Public health
27	Favour	17	Sierra Leone	F	240	89	N	Public health