Chapter 6
Excellence and Devotion: Black Women in Mathematics in the United States

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Abstract This reflective essay explores the rich history of Black women in mathematics in the United States, and their contributions to academe, research, and industry. Despite their significant activity in the field, Black women's contributions are often "hidden"—their work and research undervalued, their mentoring of others unacknowledged. This essay explores three interrelated themes—excellence, opportunity, and devotion—in the formative, educational, and professional experiences of Black women in mathematics. The essay concludes by exploring directions for future efforts to continue to build upon this group's incredible potential and achievements in mathematics. This chapter draws extensively from research conducted for and reported in the author's book about Black mathematicians, *Beyond Banneker: Black Mathematicians and the Paths to Excellence*, published by SUNY Press in 2014.

Keywords Black women • History • Mathematicians • Race • Gender

6.1 Introduction

This reflective essay explores the rich history of Black women in mathematics in the United States, and their contributions to academe, research, and industry. Despite their significant activity in the field, Black women's contributions are often "hidden"–their work and research undervalued, their mentoring of others unacknowledged. This essay explores three interrelated themes—excellence, opportunity, and devotion—in the formative, educational, and professional experiences of Black women in mathematics. Within the discussion of these themes, I analyze the unique position of Black women in a field still stratified by race and gender and trace historical events significant to Black women's interest and participation in mathematics. The essay concludes by exploring directions for future efforts to continue to build upon this group's incredible potential and achievements in mathematics.

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6.2 Establishing a Tradition of Excellence

> It is instructive to consider the extraordinary determination to succeed by some African American women mathematicians born before 1950 who faced the additional challenges posed by racism [5].

The first Black women to earn their doctorates in the United States include Euphemia Lofton Haynes (1890–1980), Evelyn Boyd Granville (1924–), Marjorie Browne (1914–1979), and Vivienne Malone-Mayes (1932–1995). But it would be incorrect to assume that Black women had not pursued advanced study in mathematics before these women received their doctorates. For example, Anna Julia Cooper (1858–1964), most widely known as a civil rights and women's rights leader, earned her bachelors (1884) and master's degrees (1887) in mathematics from Oberlin College [6] and was a teacher and principal at the M Street School in Washington, DC. M Street, which later became known as Paul Lawrence Dunbar High School in 1916, was renowned for its excellent teaching staff and accomplished graduates. Cooper eventually earned a PhD in history in 1925 from the Sorbonne, the fourth Black woman in the United States in any field to earn a doctorate (and the first from the Sorbonne) [13, 22].

Dunbar must have been a special place—because two of the first three Black women to earn their PhDs in mathematics, Euphemia Lofton Haynes and Evelyn Boyd Granville, attended this school [32]. Lofton Haynes, the first Black woman to do so, earned her doctorate in mathematics in 1943 from Catholic University. Lofton Haynes' accomplishment as the first African American woman to earn her PhD in mathematics was unknown for many years, and in fact, Marjorie Browne (PhD 1950, Michigan) and Granville (PhD 1949, Yale) at various periods were each assumed to be the first African American women to earn their PhDs in mathematics.[1] Despite the fact that some reports published around the time of Lofton Haynes' death mention her receiving her doctoral degree in 1943, no one in the mathematics community seemed to have connected the dots until the late 1990s.[2] Granville, born and raised in Washington DC herself and a fellow alumna of Dunbar and Smith College, notes "[s]urprisingly, no one in DC ever mentioned the name of Euphemia Lofton Haynes to me and I did not hear about her until late 1999. This remains a mystery to me" [32].

Born in 1890, Lofton Haynes lived in Washington, DC, for much of her life—leaving only to earn her undergraduate degree in mathematics from Smith College in 1914 and a master's degree in education from the University of Chicago in 1920. Before leaving DC for Smith and the University of Chicago, Lofton Haynes

[1] Browne finished the requirements for the doctorate in 1949, but it was not awarded until 1950.

[2] For additional information about Lofton Haynes, see Kenschaft's *Change is Possible: Stories of Women in Mathematics*. I thank an anonymous reviewer for noting that Lofton Haynes died just before the publication of Kenschaft's 1981 American Mathematical Monthly article, "Black Women in Mathematics in the United States," and thus, before Kenschaft and others could connect with her to include her in that work.

began her education in the segregated city schools of Washington, DC, attending what was then M Street School[3] and graduating from it as valedictorian [10]. A public secondary school in the nation's capital serving Black students, M Street's sterling reputation existed from the time of its founding as the Preparatory High School for Colored Youth in 1870 and in its later incarnations as M Street and Dunbar. (Dr Lofton Haynes later returned to Dunbar as the mathematics department chairperson.) From its beginning, this school was recognized for its excellence in educational opportunity and achievement. In segregated Washington, DC in 1899, for example, "in examinations given all high school students, the colored high school [M Street, at the time] scored higher than either the Eastern or the Western high schools [which were white]" [14]. As Alison Stewart writes in her book *First Class: The Legacy of Dunbar, America's First Black Public High School*, in the 1920s Dunbar's "all classical pedagogy focused on English, mathematics, the sciences, ancient history, Negro history, military drill, physical education, music, drawing, domestic science, Latin, Spanish, French and German" [30]. Dunbar and other segregated Black academic high schools of the era were staffed by administrators and teachers who often had earned advanced degrees, in many cases exceeding the qualifications of administrators and teachers at white institutions [17, 27].

While what made Euphemia Lofton Haynes decide to pursue her doctorate in mathematics is unknown, her commitment to education was clear. Teaching for 47 years in the DC public school system and also as a professor at Miner Teachers College in DC (now part of the University of the District of Columbia and where she established the mathematics department), she became a member of, and, eventually, president of the DC Board of Education. Widely acknowledged as a key proponent of integration in the DC schools in the 1960s and 70s, she was a fierce opponent of tracking in schools. She died in 1980, her status as the first Black woman to earn a PhD in mathematics largely unknown, leaving a substantial collection of her papers to Catholic University.

Many of the teachers at Dunbar, as Evelyn Boyd Granville attests and other chroniclers have described [7, 28], were highly educated and influenced their students to pursue postsecondary education. Lofton Haynes fondly remembered Miss Harriette Shadd, a teacher at Dunbar and a Smith College graduate—"I just idolized her, that's all" (Lofton Haynes oral history). It was due to Shadd's influence that Lofton Haynes wished to attend, and eventually enrolled in, Smith. When I interviewed Dr. Granville in 2009 for the book *Beyond Banneker: Black Mathematicians and the Paths to Excellence*,[4] she said the following about Dunbar [32]:

[3]Graduates of Dunbar (or M Street School, as it was first known) include luminaries such as Carter G Woodson, Charles Drew, and Mary Church Terrell.

[4]Benjamin Banneker (1731–1806) is widely acknowledged as one of the first Black "mathematical persons" in the United States. My book, *Beyond Banneker: Black Mathematicians and the Paths to Excellence*, based on archival research and in-depth interviews with thirty-five Black mathematicians who earned the PhD in a mathematical science, describes important formative, educational, and professional experiences of Black male and female mathematicians, as well as

> Dunbar gave us inspiration, quality education, and, you know, they made us feel good about ourselves...It was a tradition at Dunbar to encourage us to go to the Ivy League schools. And Miss Mary Cromwell [one of Granville's mathematics teachers] was the sister of Dr. Otelia Cromwell, a graduate of Smith in 1900, somewhere around there. Otelia Cromwell went to Smith, and then later went to Yale and got her PhD in English. And Miss Mary Cromwell and Dr. Otelia's niece [Adelaide] [7] also went to Smith. They encouraged me to apply to Smith, but I also applied to Mount Holyoke. And I was admitted to both Smith and Mount Holyoke, but I chose Smith, I'm sure at the urging of the Cromwells.

Other Black women mathematicians attending segregated schools before and during the Civil Rights era have reported similarly committed, highly educated teachers who were adamant that these young women excel in school and pursue postsecondary education [19, 21, 32]. Talented women, in general, were limited professionally to careers in teaching (and that was, for a time, only until they married). Talented Black women faced even greater odds against pursuing careers that allowed them to capitalize on their education and knowledge: in a different time, what else could Miss Harriette Shadd of M Street, Miss Mary Cromwell of Dunbar and numerous other Black women teachers who encouraged their students and provided high quality instructional experiences so that they would excel in mathematics have accomplished if given the opportunity?

Granville received her doctorate in mathematics from Yale in 1949, and then spent some time in New York City doing postdoctoral work at New York University. Eventually, she accepted a position at Fisk University in 1950, where she taught other Black women who became mathematicians, including Etta Zuber Falconer (PhD 1969, Emory University) and Vivienne Malone-Mayes (PhD 1966, University of Texas). Malone-Mayes commented that it was the presence of Granville that influenced her and others to pursue the PhD: No more than "six years older than the students she taught, [she] set high standards and demanded a quality performance from her students" [21]. Later in the 1950s and 60s, Granville began a career at IBM and NASA before returning to academe in 1967 as a professor in California and eventually retiring as the Sam A. Lindsey Professor of Mathematics at the University of Texas, Tyler. Asked once to summarize her accomplishments, Granville stated: " 'first of all, showing that women can do mathematics.' Then she added, 'Being an African-American woman, letting people know we have brains too' " [33]. Granville has received numerous honors, including honorary degrees from Smith College and Spelman College.

Lofton Haynes, Granville, Cooper, and others demonstrated excellence and did so in an era in the United States of race-based and gender-based stratification that suggested that women were incapable of scientific pursuits, and further, that sought to relegate Black women to manual labor [18]. Granville's quote—a familiar one to many Black women mathematicians—illustrates what has been called the "double bind" of being both a woman and a person of color in mathematics [25]. Despite their brainpower, Black women have struggled to find a place in the field,

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the unique historical and contemporary settings related to race, opportunity, and excellence that Black mathematicians experience.

and once there, their contributions have been sorely overlooked. Recently, attention has been deservedly given to Katherine Johnson and other women "computers" who were instrumental in facilitating the success of the early US space program [16, 26]. It is particularly gratifying that Katherine Johnson, a Black woman born in West Virginia in 1918, is the first female mathematician to be awarded the highest civilian honor in the US, the Presidential Medal of Freedom in 2015.

In Margot Shetterly's book *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race*, we learn of several Black women whose ingenuity and work was simultaneously undervalued and highly valuable, and whose career trajectories were thwarted because they were women, and because they were Black. Katherine Johnson, in particular, excelled at mathematics and other subjects throughout her educational career—indeed, she graduated from college at age 18 *summa cum laude* with degrees in mathematics and French. One of her professors at West Virginia State College, William Claytor (himself the third Black man in the US to earn his PhD in mathematics) recognized her talent and took it upon himself to ensure that she learned mathematics beyond the established curriculum. She became a teacher, and enrolled in a graduate program in mathematics (indeed, she was one of the first Black students to desegregate West Virginia University) but family commitments prevented her from completing a graduate degree. But then, as Shetterly powerfully writes: "It had always been Katherine [Johnson's] great talent to be in the right place at the right time" [26]. On a family trip in the early 1950s she learned about a mathematics job opportunity with the federal government in Hampton Roads, Virginia—at Langley Air Force Base. After a series of assignments within National Advisory Committee for Aeronautics (NACA)[5] programs, Johnson was key to the success of many of the Flight Research Division's projects, including the early spaceflights of Alan Shepard and John Glenn. Despite NACA's hiring of Black mathematics and science specialists, segregation was prevalent: for example, Black women were initially only assigned to the West Computing area of Langley, known as the "colored" computing section, and were expected to use segregated bathrooms. Johnson is one of many Black women whose stories are recounted in *Hidden Figures*—the documentation of their work exists, but has been obscured and overlooked.

These kinds of contradictions—Black women's contributions hidden in plain sight; opportunities for advancement and excellence circumscribed by a system of discrimination and inequality—are a prominent theme in the history of their mathematics pursuits in the United States. A host of factors, including their mathematical talents and interests, thwarted potential and the awareness of limited opportunity, the sense of being in the right place at the right time, the supportive and rigorous educational environment of their schools whether segregated or not, and the importance of family and community networks, all contribute to their varied paths to mathematics.

[5]NACA, founded in 1915, was incorporated into NASA in 1958.

These experiences shaped and formed these mathematicians, and, in turn, have inspired others to pursue mathematics. Their stories are largely overlooked reflections of American history, mathematics, and education across the 20th and 21st centuries. In many ways, their mathematical lives are metaphors for the Black experience in America—despite evidence of excellence, opportunities earned, granted, denied, rescinded; civil rights as citizens upheld as well as challenged; and an ever present "double-consciousness" [9] of what it means to be Black in educational and professional settings, and further, an ever present awareness of what has been called the "double-bind," "double knot," and "dual triumph" [5] of being Black and a woman in mathematics. Too often, it is a serendipitous moment that sets them on the path to achieving their full potential in mathematics. As Geraldine Darden (PhD 1967, Syracuse) recounted:

> I am not bragging, but I was a good student and was valedictorian of both my elementary and secondary graduating classes. I was the top student in my class in the Department of Mathematics at Hampton Institute. *Even so, nobody ever suggested that I go to graduate school in mathematics* [8].

Fortunately, in 1958, following increased national funding for math and science research opportunities after the Sputnik launch in 1957, Darden had the chance to study mathematics at a summer institute at North Carolina Central College. Upon her arrival, Marjorie Browne, a faculty member at Central, asked "Why aren't you in graduate school?" [7].

6.3 Opportunity in the Midst of Obstacles

> When you are both Black and Female, it is difficult to distinguish which of these traits may account for the way you are received by others. - Vivienne Malone-Mayes

The race and gender of Black women mathematicians have operated together to present unique opportunities for and obstacles to their mathematical development. US Black mathematicians, as members of an ethnic minority group within a small professional subset of individuals who are predominantly white and male often find themselves navigating largely white environments throughout their mathematical lives. For Black women, who are even more of a minority within the context of the professional community of mathematicians, these issues are magnified. In 2010, for example, only 9 doctorates (out of 863) in mathematics and statistics were earned by Black women [19]. In 2014–2015, of the 1901 new PhD holders in the mathematical sciences in 2014–2015, 880 of those (or 46%) were US citizens [31]. Of the US citizens earning the PhD, 20 were Black (10 Black women, 10 Black men) [1, 31].

But it should be noted that the Black women mathematicians interviewed for *Beyond Banneker* reported few gender-related obstacles to their mathematics progress during childhood and adolescence. As Vivienne Malone-Mayes (PhD 1966) stated about her school experiences in segregated Texas, "Black girls were expected to excel in their studies. No difference was made between boys and girls."

Indeed, when Black women mathematicians describe their learning experiences in school as children and adolescents, they largely describe classrooms in which girls are expected to perform as well as boys, and further, teachers who identified them as talented in mathematics and nurtured that talent [1, 2, 17, 32].

Further, when these girls grew up, expectations related to their gender certainly included marriage and motherhood, but for many of them, it also included working outside the home. As Malone-Mayes stated, "The moral lectures given by teachers and designed to stimulate students to aspire to high and lofty careers were directed equally to boys and girls. Every girl expected to work...Boys expected girls to work. Within our homes were working mothers" [21]. Indeed, it is important to note, that at least historically, "the African American community did not place as many restrictions on women as did the general culture" [5] in terms of gender roles in schools and professions. States Gloria Hewitt, the fourth Black woman to receive her PhD in mathematics: "Black women were always expected to work. The question was, at what?" [23]. One particularly moving story from *Hidden Figures* centers on Mary Jackson, a Black woman and award-winning NASA engineer, and her son, Levi. Working with his mother on his car's design, Levi entered a soapbox derby race in 1960 and won. He was quoted in the local Norfolk newspaper as saying "I want to be an engineer like my mother [when I grow up]" [26]. Mayes, the 5th Black woman mathematician to earn her PhD, said that within the Black community "girls were conditioned from my earliest recollection to prepare to work, [with the hope] that through education [they] could escape the extremely low paying jobs designated for Black women" [21].

The women mathematicians interviewed for *Beyond Banneker* reported that their gender was not an issue in terms of their mathematics pursuits in childhood and adolescence. In *Beyond Banneker*, one mathematician described her time in elementary and secondary school:

> Nobody ever made it seem like math and science should be hard, and so I think I just ended up doing well in it, because I didn't know it was supposed to be difficult or had to be difficult. But I think some people feel like it's just supposed to be hard or something, and I just never felt that way [32].

And for the most part, whether they earned their doctorates 10 or 60 years ago, there were very few instances of Black women reporting issues related to gender in their undergraduate experiences, whether those experiences were at historically Black colleges and universities or predominantly white institutions. One exception is particularly jarring, however:

> There was one really well-renowned professor at [my undergraduate institution] who basically told me, "Pick another major", because I was a math major when I first started out. I wanted to be a math major. I later found out from a white female post-doc [that] he was definitely sexist. She didn't even go into whether he was racist or not, but it definitely came out later that he was definitely sexist and he still thought math should be a male thing. That was the main reason I didn't major in math in college. I was 17 and impressionable, and here's this big name person telling me this, so I kind of believed it at the time [32].

Most women interviewed for *Beyond Banneker*, and many Black women mathematicians, reported that their gender became increasingly salient to how they were perceived as mathematics doers as they advanced through postsecondary education [15].

> Q: Did you feel any other times that you were isolated from others in mathematics?
> A: No, I don't think I ever did. I was really lucky. I don't think I ever felt isolated, because I had a group of friends—as I said, were in the AP classes [in high school] together, but even when we were in elementary school, we were all kind of...I don't want to say we were nerdy, but we all had an interest in math and science and all worked really hard. In college and grad school, I felt isolated, not because I'm not interested in math, but because I'm the only African American in the room, and sometimes the only female [32].

Graduate school can be particularly difficult for those who are underrepresented in graduate mathematics—women and members of ethnic minority groups [5, 15, 24]. If their ability in mathematics was not challenged before, as it had not been in high school or undergraduate studies, graduate school can become a kind of crucible for some mathematicians. This is undoubtedly true for many doctoral students, but for Black students, the overlay of race and perceptions of ability are vividly present in their descriptions of these experiences. For Black women, particularly those who attended HBCUs, it is often the first time that they are confronted with the "double knot" of race and gender—those who have low expectations of their mathematics ability because of their gender, and those who have low expectations of their mathematics ability because of their racial background. Malone-Mayes, attending her first graduate courses at the University of Texas in the 1960s, reported that she "was the only Black and the only woman. For nine weeks, thirty or forty White men ignored me completely. I never initiated any conversations as there was no encouragement to do so. It seemed to me that conversations before class on mathematics quickly terminated if it appeared that I was listening" [21]. One mathematician interviewed for *Beyond Banneker*, speaking decades after Malone-Mayes, reported:

> The women I know that went to big majority schools and try to be a math major get crushed. So the women in graduate programs tend to come from smaller schools. So forget about race, forget about gender, so maybe that's how they don't fit the successful graduate school package. Or coming from the South, you know, because people have all kinds of judgments about that. I mean, everything plays into it [32].

Another Black woman in graduate school in the 1990s took it upon herself to create study groups:

> So that first year I sent out this email and said that we were going to meet on Wednesday for lunch and then we were gonna work on our homework together in the library. And I just sent it to all the first year students. And people were like, "oh, okay". I mean like they were cool. Everybody showed up. We did that every Wednesday...And it really helped us to grow, but the only reason I did it was because I was like 'nobody is just gonna reach out to me to form a study group unless I form one myself'....It was so not official. It was just me deciding that I would rather we all work together so we could all learn from each other [32].

All of these experiences are challenging, and reflect that it requires more than mathematics talent to navigate graduate school. Now it is true that the women

interviewed for *Beyond Banneker* are a select group who persisted in mathematics through the PhD, and so it is quite possible that Black women experience more acts of racism and/or sexism that discourage them from pursuing mathematics than are recounted by Black women who have been successful in attaining the PhD. But for these women, it is in graduate school where Black women seem to experience acts of sexism and racism.

Mathematics is still a field where a common trope about women in mathematics is that women cannot do mathematics at a high level, exacerbated by commonly recounted prejudices by people in the popular press, professors, and even a university president.[6] (Some female mathematicians report instances where they were encouraged to leave their doctoral programs despite passing qualifying exams, because "no one" was interested in working with them.) Less common nowadays, one hopes, is the supposition that women don't "need" PhDs because their husbands will have one.

> The graduate chair called and gave me this nice, long conversation. He told me I didn't need a Ph.D....That my husband's going to have one and it would be too hard for both of us to get a job if we both had a Ph.D....I just dismissed him. I thought that was outrageous but I did not say anything there [32].

But there are still instances where Black women mathematicians feel that their gender is a problem for their colleagues and faculty at their graduate institutions. Among those interviewed for *Beyond Banneker*, Black women were more likely than Black men to mention the "graduate school switch"—earning the master's at one institution, then finishing the PhD at another. All who mentioned this—male and female—pointed to acts of racism, either at the institution or within the department.

About her initial graduate school experience one mathematician noted:

> [That place] was traumatic. My self esteem took a beating. It was a very, very difficult time. The department was mostly comprised of white men who first of all did not feel like women could do math, let alone Black women, let alone a Black woman from a Black college. I just had too many strikes against me...That was one of the worst times of my life [32].

Her next graduate school experience was much more positive, largely due to the efforts of the department chair at the time:

> The department was bigger, so there was more [faculty diversity]. He [the department chair] made a concerted effort to really recruit Black students to the program, so there was a big network of Black students there at all levels so they could help each other as they went through the process...Even with the white faculty it was a different feel. I didn't get that same sense of lack of belief in me. I think that grad school, in their minds, was a weeding out process for everybody, not just a select group of people. At [her first graduate institution], I felt like we were singled out. At [the second], they were like, "No. Grad school is hard. You've got to work hard." I respected that and I planned to work hard. Just give me the chance to work hard. It was a different feel. It was a much better environment [32].

[6]Lawrence Summers, then President of Harvard University, made remarks about the potential for innate differences between women's and men's abilities to do science at a high level at a National Bureau of Economic Research luncheon in 2005. See, for example, http://www.harvard.edu/president/speeches/summers_2005/nber.php.

Black women are still a significant minority in graduate programs in mathematics, and as mathematics department faculty in most institutions.

> My graduate program was a culture shock. So, I was like the only woman and African American pretty much. In the first year class there were like 9 of us. There were three Hispanic guys, there was a Russian guy, two white guys, a couple Asians. I mean it was a very diverse group. But yeah, it was definitely different. I remember I would get called out when I would miss class because it was so noticeable. I mean it was just so obvious when I wasn't there because I was the only female and the only Black person. You know? I did feel like I stood out a lot more. It was just easy to notice if I was somewhere or not. The faculty were very supportive. I never felt like they didn't want me to succeed or anything. There was a Black woman who had graduated the summer that I started. And so I actually took her desk, took her office spot. But yeah, they were very supportive of African Americans. But it was just different. It was definitely a culture shock [32].

Etta Falconer, in her paper "The Challenge of Diversity" published in 1997, discussed several issues related to diversity in mathematics. In particular, she urges that "action must be taken to bring more women into the mathematics community as full partners and a few stars are not enough" [11]. In her continuing discussion of issues facing underrepresented people of color in mathematics, a section devoted to "the effect of culture shock" described the costs of being the only woman or person of color, or one of a few women or underrepresented persons of color in college or graduate mathematics. She noted that in predominantly white postsecondary environments "minorities must spend time and energy learning different patterns, values and behaviors" while "majority students can devote this same amount of time and energy to their studies" [11]. The feeling of being "singled out" relates to Claude Steele's description and analysis of how individuals (regardless of demographic background) respond to a perceived "spotlight" effect when they participate in activities where they are in the minority, and that can contribute to depressed demonstration of one's academic talent [29]. Steele calls this situational effect when one has the potential to confirm a negative stereotype about one's group, "stereotype threat," and it has been documented to have an impact on groups such as women in mathematics and African American college students. The impact of stereotype threat is most present for people who are strongly identified with the domain in question—that is, the impact of stereotype threat on mathematics performance could be particularly significant for women who consider themselves "math people."

Undoubtedly, Black women have experienced greater opportunities to pursue mathematics in education and as a profession in the United States over time. But there are still barriers, and it is sobering to think of women (the aforementioned teachers at Dunbar and other segregated schools, for example) whose opportunity to pursue advanced degrees and careers in mathematics was limited. Several mathematicians, male and female, in *Beyond Banneker* told vivid stories of thwarted talent within their families and communities. For example, Evelyn Boyd Granville recalled:

> I think my sister was good in math. But I don't remember exactly; I know she started college. But she didn't finish, she stayed one year and then she didn't finish. I don't know whether

she was going to be a math major or not. I think she was pretty good. Now, my mother, I don't recall my mother being particularly adept at mathematics. And of course my mother didn't go to college, my father didn't go to college, so *I don't know what their real strengths would have been had they been living in this current situation, today* [emphasis mine] [32].

6.4 Dedication and Devotion

I have devoted my entire life to increasing the number of highly qualified African Americans in mathematics and mathematics-related careers. High expectations, the building of self-confidence, and the creation of a nurturing environment have been essential components for the success of these students. They have fully justified my beliefs. Perhaps the most rewarding moments have come when younger faculty have undertaken the same goal and have surpassed my efforts, reaching out to the broader community to help minorities and women achieve in mathematics. - Etta Z Falconer, upon receiving the AWM Louise Hay Award in 1995

Throughout the narratives of Black women mathematicians shared in various essays, articles, and books, there is a prominent theme of devotion. Black women mathematicians exert influence and model successful practices in numerous ways—through their research, teaching, mentoring, program development, advocacy, and service. They are active in and have won awards for their research, teaching, mentoring, and service in professional organizations such as the American Association for the Advancement of Science (AAAS), Association for Women in Mathematics (AWM), Mathematical Association of America (MAA), and the National Association of Mathematicians (NAM), among others. In addition to the 1995 Louise Hay award bestowed upon her by the Association for Women in Mathematics, Falconer was elected a fellow of the AAAS and received its 2002 AAAS Mentor Award for Lifetime Achievement. Experienced women—whether they are those who have reached their career goals or those who may not themselves have accomplished all that they are capable of—support younger women who enter the profession after them. For example, Dorothy Vaughan, one of the first Black women hired as a mathematician at Langley, had worked as a math teacher. When not teaching, in wartime summers, she also worked in the laundry room at a military base in Virginia. As the West Computing section head at Langley, she mentored Katherine Johnson and numerous other women.

The extensive research on women's colleges demonstrates that women who attend these institutions thrive in terms of challenging stereotypes and experiencing success in their careers, particularly those careers in science, technology, engineering, and mathematics. Spelman College, founded in 1881 for the higher education of Black women, has been an exemplar in graduating women who go on to earn doctorates in STEM careers for decades. In fact, Spelman, on a per-student basis, "produces more African Americans who earn doctorates in the STEM fields than any college or university in America" [12].

As a physical space, the Albro-Falconer-Manley Building, also known as the "Science Building," on Spelman's campus has immediate visual impact. The Sci-

ence Building is named for three women in the sciences (two of whom are Black American) with influential careers at Spelman: Helen Albro, Etta Falconer, and Audrey Forbes Manley. When one enters the building, the first thing one sees is an atrium with museum display cases, photographs, and other artifacts documenting the impressive history of women in the sciences at Spelman.

For Black women mathematicians in particular, including five Spelman alumni and professors who were interviewed for *Beyond Banneker*, the influence of Etta Falconer (1933–2002), who earned her PhD in mathematics in 1969 from Emory University, looms large over the science and mathematics programs at Spelman, as well as mathematics organizations and departments at other institutions.

Several mathematicians who are now college and university faculty spoke of Dr. Falconer's approach to insuring that students and alumni of Spelman were successful in their graduate science programs. One, Sylvia Bozeman, now retired from a distinguished career as a faculty member and administrator at Spelman, has won awards for her teaching and service to Spelman and the profession and was the first African American to be elected a Section Governor of MAA (in 1997 as the Southeastern Section Governor). Bozeman began her career as a mathematics instructor at Spelman and described Dr. Falconer's support for her completing the PhD and professional trajectory:

> You know, I had the best mentor for 30 years here at Spelman; Dr. Etta Falconer, and she was just incomparable as a mentor. So I came as really green, right out, with a master's degree. And so I just learned so much from her.
> She had the just most wonderful devoted following among all of us here in the sciences, because she didn't just mentor me, she mentored lots of faculty, lots of staff, and many more students. There were just lines of students outside her door all the time. Even her administrative assistant or secretaries, you know, they all went to school and left her. They all moved up. She mentored everybody [32].

A Spelman graduate who herself earned her PhD within the last 15 years was mentored both by Falconer and Bozeman, and, like others, also attributed Spelman's success in the sciences to Etta Falconer and her colleagues' lasting influence:

> Etta Falconer mentored me. I mean, she was the oldest person at Spelman, she was really responsible for this sort of renaissance of science at Spelman.
> And she was old school, she just kind of told you what to do, like, "You're going to present here," and, "You're going to do this," and, "You're wrong, you're right." So it wasn't a nurturing kind of mentoring, she just kind of told it [32].

These relationships continued long after students left Spelman. Graduates interviewed for *Beyond Banneker* reported that Falconer invited them to return to Spelman to speak to undergraduate majors about their careers, frequently gave advice at professional meetings, and encouraged them and supported the development of their research agenda. A Spelman graduate who is now a mathematician reported:

> Spelman was the first time I saw Black women with Ph.D.s in math, which I think has a very interesting impact. I think I only recognized it in hindsight because when I was there I sort of took it for granted. We had about five or six Black women on faculty that had Ph.D.s, and I just thought, "Oh, they're a dime a dozen." And it wasn't until my junior year that I

> realized there were fewer than 100 Black women who had ever gotten Ph.D.s in math. Not only that, to know that if I got one in five years I would still be in the top 100. It was just blasphemy [32].

An organization that focuses on the recruitment and retention of diverse women in mathematics, EDGE (Enhancing Diversity in Graduate Education), was founded by Sylvia Bozeman and her colleague at Bryn Mawr, Rhonda Hughes. EDGE brings small cohorts of diverse women entering graduate school together in the summers and provides mentoring (by EDGE alumni and faculty) year-round and for the duration of their graduate school careers and beyond [4] (also see chapter 20 in this volume). Several mathematicians (male and female) interviewed for *Beyond Banneker* have worked with EDGE, either participating themselves when they were graduate students as mentors and mentees, or teaching during the EDGE program. As one woman mathematician stated:

> That EDGE program is priceless. I cannot say enough positive things about what that program does and continues to do even with the cohort that we built. As we progressed, we still are in contact with each other. So it is helping even now at this level in my life [32].

Many Black women mathematicians through formal programs like EDGE or more informally through their everyday practice are deeply committed to increasing the participation of women and people of color in mathematics. Another former participant, now a university faculty member, stated:

> Probably, definitely the first important thing for me is this continuing to add more African American Ph.Ds and women to mathematics. Probably people will be saying that I am too young for this to be my most important thing, but because I was so influenced, I feel obligated to pass that on. So to get students excited about math and about deep math, that is my main focus. After that is probably the research. I know that if I can't keep it up, I can't pass it down because my advisor did not do research. [My advisor's] life is not quite fulfilled because of that. For me, I realized that that is something that I need to do [32].

Their dedication and devotion, however, can be a double-edged sword. Several mathematicians spoke about the significant service requirements (both at their colleges and universities and in the profession) that seem to fall disproportionately on Black women faculty. At times their extensive service is to the detriment of their health and career advancement.

6.5 Conclusion

The often hidden histories of Black women mathematicians in the United States reveal much about how they come to do mathematics in multiple contexts—home, school, community, college, university, and the profession, whether academe or industry. Although these mathematicians have varied paths to the profession, they share a common social and cultural bond—they are Black women in the United States.

While this is not to suggest that all African American women mathematicians have exactly the same experiences, there are significant commonalities. Too often, their paths to mathematics, despite their exhibited excellence, were in danger of being stymied for reasons of racism and sexism. In particular, younger Black mathematicians find themselves, still, at a curious intersection of race, gender, and opportunity. While opportunities are much more widely available for them than for those who came before them, they are still subject to sometimes hidden and sometimes stunningly explicit negative discourses about race, gender, and merit. Throughout their mathematical journeys, they may find themselves members of a very small group of Black students in mathematics classrooms in their high schools, colleges, and universities, and further, may have to address negative perceptions of their mathematical preparedness and expertise in graduate school classrooms. They ponder what happens to other students, who may be equally talented, whose parents may lack the advocacy skills needed to insure placement in advanced mathematics classes in schools, or to those who take the advice of professors that perhaps the mathematics major is not for them.

For many women, at critical transition points (graduating from high school to entering college as a math major; going from the undergraduate degree to graduate program; taking coursework and qualifying exams to completing the dissertation) there were gateways to mathematics that were provided by high school teachers and college and university faculty. Some of these moments could only be called serendipitous—in that there was great potential for these mathematicians to be overlooked as strong, or potentially strong, mathematics students. These doors could have easily remained closed, if not for Black women mathematicians who guided them, but also men and women of all backgrounds who championed them despite the prevailing rhetoric and practices that could have undermined their capability.[7] In 2000, three Black women, Tasha Inniss, Sherry Scott-Joseph, and Kimberly Weems graduated with their PhDs in mathematics from the University of Maryland [17]. They were the first Black women to do so from that department, and it was the first time that multiple Black women had earned their doctorates in one year from a university that was not an HBCU. They acknowledged that structures and practices of the department chairperson, Raymond Johnson, himself a Black mathematician, had created an inclusive, rigorous, and supportive environment [20].

Aside from the potential pitfalls of these critical transition points, there are some obvious examples of practices and policies that promote Black mathematicians' success [2, 3]. A common refrain in the narratives that older Black mathematicians share about their mathematical journeys is the importance of the 1957 Sputnik launch. The desire to best the Russians led to an unprecedented US investment in science, technology, engineering, and mathematics education at all levels. Increased funding for multiple types of programs for science, technology, engineering, and mathematics benefited many mathematicians, and especially Black and female

[7]For example, Lee Lorch has been discussed often as a strong supporter of African Americans in mathematics in general, and African American women in particular.

mathematicians. Mathematicians who were excellent high school students in math attended summer and Saturday STEM programs at universities and colleges; mathematics majors in college participated in summer research experiences funded by the National Science Foundation and were hired by faculty as research and teaching assistants under the auspices of professional development programs for minority mathematicians. Without this funding stream, it is possible that many mathematicians may not have had this exposure during that particular time period, when segregation was still prevalent. Indeed, the Black women "computers" and mathematicians at NACA and NASA are obvious beneficiaries of this moment in American history. This history and the increased participation of talented Black women in mathematics at that time speak to the value of continued and increased funding for such programs. But in a country that prides itself on being a place where every American can reach her God-given potential through hard work, we should not need such national imperatives to ensure access and opportunity to talented Americans, whatever their race or gender.

Too many talented math students in high school and college continue to be largely unaware of the opportunities that their mathematics prowess can bring them. Some of the women mathematicians whose stories are recounted here were largely unaware that they could go to graduate school for mathematics until quite late in their undergraduate college years. Quite a few "backed into" mathematics careers, with many assuming that they would be high school teachers or else, advised by well meaning teachers or adults, were steered into engineering or accounting. While there is nothing wrong with these careers, for some it was somewhat by chance that they happened to discover opportunities for graduate mathematics programs and that they, in reality, preferred the study of mathematics to other disciplines. In short, the pipeline to graduate study in mathematics does not start in college. Mathematicians and educators, whether they are in academe, industry, or government, should work to ensure that information and guidance about careers in mathematics are available to young people in secondary school or earlier.

Many Black women mathematicians are adamant about this mission to increase participation in mathematics, and thus take a long view of their work: they develop networks that persist long after students graduate from college, and the strong relationships between undergraduate faculty and alumni continue throughout their professional careers. They view their professional identities as encompassing not just their research and teaching, but also a "mission" to attract others to the field and the desire to "pass things on."

Black women mathematicians across generations have issued a call to action. And while they are convinced that mathematics as a discipline is a worthwhile endeavor, they acknowledge that practices and structures within the broader mathematics community do not necessarily support or invite Blacks into the field. However, they mentor others and craft environments and initiatives that facilitate the development of mathematics excellence for those who find existing structures unwelcome. Much of the work they do to bring others in the field is rooted in

history and memory, and comprise deliberate practices to facilitate their own success and as well as the success of others. Too much of this work, which benefits many, irrespective of race and gender, is underappreciated and unrecognized.

Finally, there are too many stories of Black women's interest and excellence in mathematics that remain untold. These hidden stories, and the recently discovered histories of mathematicians like Euphemia Lofton Haynes, Katherine Johnson, and others, should make us wonder what we have missed learning about the people who know, love, and do mathematics. There are some who argue, strongly, that young people who exhibit keen mathematics talent will always be discovered and supported. The sheer number of potential missed opportunities to pursue and persist in mathematics for many of the mathematicians described here should counter that argument. It is up to all of us to ensure that we continue to identify and develop mathematical talent, whomever has it and wherever we find it, and that untold stories are shared, preserved, and not forgotten. Black women's mathematical talents are a "gift to the world"[8] and should be acknowledged as such. One hundred years from now, let us be able to see so many Black women mathematicians as to render their presence in the profession commonplace and unremarkable. Let us commit to ensuring that their excellence and devotion are rewarded with opportunity and inclusion.

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[8]The mayor of Atlanta, Kasim Reed, speaking at the inauguration of Spelman's 10th president in 2016, said that Spelman College "is a gift to the city, and to the world".

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