MEMORIAL TRIBUTE

The Legacy of Evelyn Boyd Granville (1924–2023)

Johnny L. Houston

Figure 1.

An internationally recognized mathematician, computer scientist, scientist / engineer, scholar, educator, mentor, and pioneer / barrier breaker has departed. Dr. Evelyn Boyd Granville is the *second* known Black woman[1] to earn a PhD in mathematics. She died peacefully on June 27, 2023 in her Silver Spring, Maryland, home at the age of 99. She performed pioneering work in **academia** [Smith College, Yale University, New York University, Fisk University, California State University at Los Angeles, University of Texas at Tyler, and Texas College], in **government** [National Bureau of Standards (NBS)/Diamond Ordnance Fuze Laboratories/National Aeronautics and Space Administration (NASA)], and in **industry** [International Business Machines (IBM)/US Space Technology Laboratory (USSTL)/North America Aviation (NAA)].

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[1]*Euphemia Lofton Haynes, Catholic University, 1943; Evelyn Boyd Granville, Yale University, 1949; Marjorie Lee Browne, University of Michigan, 1950; are the three first known Black women to earn a PhD in mathematics.*

Early Years

Figure 2.

Evelyn Boyd was born on May 1, 1924 in Washington DC. She was the second daughter of William and Julia Walker Boyd. After her parents separated when she was young, she and her sister Doris were raised by her mother and their mother's twin sister Louise. Both her mother and Aunt Louise worked as examiners for the US Bureau of Engraving and Printing. Evelyn and Doris often spent portions of the summer at the farm of a family friend in Linden, Virginia. Their mother and Aunt Louise came from a large family in Orange County, Virginia. However, the family was small in DC. Doris had one son, Kurt Barnes, and Evelyn had no children. During most of Evelyn's childhood, the family lived on 2336 Ontario Rd, the homestead from which Evelyn recalls walking to elementary school, junior high and high school. Because of segregation, there were only three high schools for Blacks in DC at the time (Dunbar—academic, Armstrong—tech, and Cardoza—business). Evelyn attended Dunbar and was one of five valedictorians for the class of 1941.

After Dunbar, Attending College

Seeking an opportunity to go to college, Evelyn applied to the women's colleges of Smith and Mount Holyoke, both in Massachusetts. She was accepted at both colleges, but she did not receive a scholarship from either one. Evelyn

preferred Smith based on her having met a Black professional lady in DC that she admired who attended Smith. Since her family wanted her to attend a reputable college in the north, they decided to cover Smith's annual cost of $1100 for tuition, room and board for year one. Her mother gave Evelyn $500 and Aunt Louise also gave her $500. Moreover, a professional organization of Black educators, Phi Delta Kappa, gave her a $400 scholarship, which was $100 each year for four years. Beginning with her second year, Smith gave Evelyn a partial scholarship annually and she worked part-time at Smith. With support from her mother and Aunt Louise, and her summer work at the National Bureau of Standards, Evelyn had a comfortable and successful college career. Evelyn entered Smith in the fall of 1941 with the intention of becoming a French teacher, but mathematics, physics, and astronomy drew her away from "uninteresting" French literature. She was elected to Phi Beta Kappa and graduated summa cum laude in 1945 with a bachelor's degree in mathematics and physics.

After Smith, Earning a PhD in Mathematics from Yale/Teaching at NYU and Fisk

Figure 3. L–R: Dr. Vivienne Malone Mayes, Dr. Boyd, and Dr. Etta Falconer.

Evelyn won awards for graduate study (she applied to and was accepted at Yale University and the University of Michigan). These included a Smith Fellowship, a Julius Rosenwald Fellowship, and an Atomic Energy Fellowship. She entered Yale in the fall of 1945, earning a Master's of Arts degree in 1946 (math) and a PhD degree (math) in 1949 under the renowned Functional Analyst, Einar Hille. She was elected to the scientific honorary society, Sigma Xi, and her dissertation was entitled: "On Laguerre Series in the Complex Domain." After earning her PhD, Dr. Boyd did a one-year post-doctorate at New York University Courant Institute for Mathematics, performing research and teaching. From 1950 to 1952, Dr. Boyd was an associate professor at Fisk University, a historically Black college (HBCU) in Nashville, Tennessee. At Fisk, Dr. Lee Lorch was chair of mathematics and Vivienne Malone Mayes and Etta Zuber Falconer were two of Dr. Boyd's students who later earned a PhD degree in mathematics.

Careers Outside of Academia in the 1950s

Figure 4. Dr. Boyd showing a young man, how they programmed the orbits of space vehicles.

In 1952 Dr. Boyd was recruited to become an applied mathematician at the *National Bureau of Standards* (NBS) in Washington, DC, where she worked on missile fuses. Her division of NBS was later absorbed by the United States Army and became the Diamond Ordnance Fuze Laboratories. There she became interested in the new field of computer programming. Dr. Boyd Wrote: "This work entailed consulting with Ordnance engineers and scientists on the mathematical analysis of problems related to the development of missile fuses…I met several mathematicians who were employed…as computer programmers."

At that time the development of electronic computers was in its infancy. Dr. Boyd recalled:

> "The application of computers to scientific studies interested me very much, which led to my giving serious consideration to an offer of employment from International Business Machines Corporation."

In 1956, another door opened for Dr. Boyd. She was recruited by the corporation, *International Business Machines* (IBM), where she was immediately seated before a 650 Magnetic Drum Data-Processing Machine and asked to do computer programming. At first, she worked in Washington, writing programs in the assembly language SOAP and later in the programing language FORTRAN for the IBM 650, which was the first computer intended for use in businesses, and for the IBM 704. In 1957 she moved to New

Figure 5. The Space Team on which Dr. Boyd worked consisted mostly of white men; she was always the only Black.

Figure 6. The *Vanguard* satellite and the manned *Mercury* spaceship, the first two vehicles for which Dr. Boyd helped to write computer programs to put in orbit around the Earth.

York City to take up a post as a consultant on numerical analysis at the New York City *Data Processing Center of the Service Bureau Corporation*, which was part of IBM. When the United States space program began to move rapidly forward, the *National Aeronautics and Space Administration* (NASA) contracted IBM to write software for them. She was then assigned to join IBM's Vanguard Computing Center in Washington, DC, where she wrote computer programs that tracked orbits for the unmanned Vanguard satellite and the manned Mercury spacecraft. Dr. Boyd was happy to return to Washington DC to be on a team of IBM mathematicians for this assignment. Dr. Boyd stated:

> **"I can say without a doubt that this was the most interesting job of my lifetime—to be a member of a group responsible for writing computer programs to track the paths of vehicles in space."**

It is noteworthy that Dr. Boyd studied astronomy at Smith, earned degrees in mathematics and physics there, and became an expert in computer science before it became a recognized discipline.

Figure 7. Dr. Evelyn Boyd Granville at her computer/printer.

Careers Outside of Academia in the 1960s

Dr. Boyd left IBM in 1960 to move to Los Angeles, where she participated in research studies on methods of orbit computation with the *Computation and Data Reduction Center* in the aerospace firm: *United States Space Technology Laboratories*. She did further work there on satellite orbits. In 1962, she joined the aerospace firm in Los Angeles, California named, *North American Aviation* (NAA). With NAA, she became a research specialist in celestial mechanics, trajectory, and orbit computation, and developed digital computer techniques for engineers working on the Apollo project. Dr. Boyd returned to IBM in 1963 and joined its *Federal Systems Division* in Los Angeles as a senior mathematician. In 1967, IBM was reorganizing and asked her to relocate to their division in Northern California; however, she declined. She decided that she wanted to remain in Southern California.

In 1960, Dr. Boyd married her first husband, Rev. Gamaliel Mansfield Collins. One of her great memories from that marriage was her husband's close affiliation with the Rev. Dr. Martin Luther King, Jr. This affiliation caused her and her nephew Kurt Barnes to have premier seats on the steps of the Lincoln Monument when Dr. King gave his "I Have a Dream Speech" during the March on Washington (August 28, 1963). In several of her presentations/speeches, she mentioned the impact of this experience on her life. This marriage ended in 1967. Before we chronologically follow her latter years in teaching, education, and mentoring, the author wishes to share a second human interest story that occurred during her outside of academic careers in the 1950s–1960s.

John Glenn, Dr. Katherine G. Johnson, and Dr. Evelyn Boyd Granville All Agreed

Figure 8. Dr. Katherine G. Johnson with her calculator and globe.

On October 4, 1957, a Soviet R-7 intercontinental ballistic missile launched *Sputnik* (Russian for "traveler"). This was the world's first artificial satellite and first manmade object to be placed into the Earth's orbit. *Sputnik*'s launch came as a surprise. In April 1961, the Soviet cosmonaut Yuri Gagarin became the first person to orbit earth, traveling in the capsule-like spacecraft Vostok 1. For the US effort to send a man into space, Project Mercury was established.

Created in 1958, NASA engineers designed a smaller, cone-shaped capsule far lighter than Vostok. They tested the craft with chimpanzees and held a final test flight in March 1961. This was before the Soviets were able to pull ahead with Gagarin's launch. On May 5, 1961, astronaut Alan Shepard became the first American in space, though not in orbit. Later that month on May 25, 1961, **President John F. Kennedy made the bold, public prediction, before a Special Session of Congress: "the US will land a man on the moon before the end of the decade." In February 1962, John Glenn became the first American to orbit the Earth.** By the end of that year, the foundations of NASA's lunar landing program had been established with Project Apollo. Before agreeing to be the first American astronaut to orbit the earth, John Glenn insisted on reviewing the calculations for orbit trajectories calculated by computers on Dr. Boyd's team and other teams. He then insisted that the "Human Computer," Katherine G. Johnson (as recounted in the book and movie*: Hidden Figures*), validate by hand the orbit trajectory results that had been calculated by the computer teams. Johnson validated the results that the computer calculations had produced. John Glenn then agreed to fly around the earth. These two African American mathematicians played fundamental roles in the early successes for both the development of the American Space Age and in NASA honoring the bold prediction of placing a man on the moon in the 1960s, as President Kennedy stated in 1961. On July 20, 1969 American astronauts Neil Armstrong (1930–2012) and Edwin "Buzz" Aldrin (1930–) became the first humans on the moon.

These Two Pioneers Never Met or Communicated, but the World Knows Both

Figure 9. Mr. Edward V. Granville and Dr. Boyd.

Although the pioneering contributions of these two Black mathematicians were not recognized by the public and by historians in earlier times, they have become clearly recognized in recent years. It is interesting to note that these two mathematicians never met or communicated; however, both lived beyond 99 years, and both recently, passed (Johnson: August 26, 1918–February 24, 2020; Granville: May 1, 1924–June 27, 2023). When the book and movie: *Hidden Figures* were shared with the world in 2017, they were no longer hidden from the public. Both of these ladies lived long enough to be able to go to the theater to see the movie and to recognize some of the notice that they were receiving. At its 50th Anniversary Celebration in Baltimore (January 18, 2019), the National Association of Mathematicians (NAM), recognized both mathematicians: Dr. Johnson with a Centenarian Award and Dr. Granville with a 50th Anniversary Legacy Award. The author last saw and spoke with Dr. Granville in person at this event when both of these pioneering mathematicians were still alive.

Dr. Granville Was the Exception, But She Knew About Segregation/Racism/Sexism First Hand

At North American Aviation and IBM, she was part of divisions aiding the Apollo missions and also providing technical support to engineers working on moon landing calculations years ahead of the first steps on the lunar surface in 1969. In the year 2000, in Texas she told the *Tyler Morning Telegraph*: "There was such a need for talent, that companies stopped looking at race and gender."

That was true, up to a point. She just happened to be part of a small cadre of women involved in the space program. Moreover, Dr. Granville had exceptional skills in mathematics, physics, and computer programming. Often times she was the only woman *and* the only Black person on her team. But Dr. Granville also knew segregation and sexism firsthand. She often lamented that women and minorities remained significantly underrepresented in mathematics and the sciences. She spent her childhood in Washington, DC, and did all her education before college in the segregated education system of Washington, DC. As she wrote in 1989 for the scholarly journal *Sage*: "We accepted education as the means to rise above the limitations that a prejudiced society endeavored to place upon us."

Return to Academia

Figure 10.

After nearly two decades in the private sector and government, Dr. Boyd decided to return to academia. Although she thoroughly enjoyed her two years at Fisk, it should be noted that at the end of her post doc year, Dr. Boyd applied to white institutions with PhD programs in mathematics who had advertised entry faculty openings in their mathematics department. However, none of them offered her an interview, even though she had a PhD in mathematics from Yale, impeccable credentials, and her advisor, Prof. Einar

Hille, had been a former president of the American Mathematical Society (AMS). Dr. Boyd once wrote:

"Early in life, I saw black women, well-dressed women—teaching school, and I wanted to be a teacher. . . "

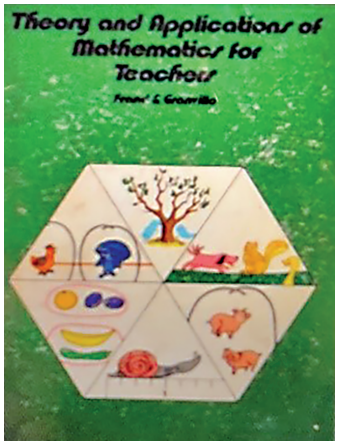

Figure 11. First Edition of Dr. Granville's book.

In 1967, she applied for a faculty position in the mathematics department at California State University, LA. She was hired and rose to the rank of a full professor before retiring in 1984. Her pay in academia was at least a 50 percent cut from what her pay had been in the private sector. In 1970, she married her second husband, Edward V. Granville, a realtor in LA. After this marriage, she used the name, *Evelyn Boyd Granville*.

At California State University in Los Angeles, she taught several courses in mathematics and computer science, including numerical analysis and a course required for all persons aspiring to become elementary school teachers. The latter course caused her to develop a real interest in mathematics education for the training of elementary school teachers. This interest in mathematical education led to her involvement with the *Miller Mathematics Improvement Program* and as part of this program she taught mathematics for two hours each day at an elementary school in Los Angeles during the 1968–1969 academic year. Out of this experience came her joint publication with a colleague at CSU, LA, Jason Frand. The title of the book is *Theory and Applications of Mathematics for Teachers* (1975). The book was well received and adopted by 50 or more institutions of higher learning. Three years later a second edition was published but fashions changed in the teaching of mathematics and soon after the second edition ceased to be as relevant as the first edition. She wrote:

> *My husband was born and raised in East Texas and had planned to return to the area when he retired from his business. I often accompanied him on visits to Texas and, after making several trips, I was convinced that a move to a rural setting in East Texas would be a welcome change from the Los Angeles metropolis. We found an ideal setting near Tyler, Texas.*

Figure 12.

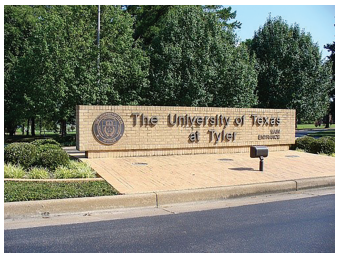

Figure 13.

In 1984, she and Edward V. Granville left Los Angeles to live on this rural 16-acre plot, and a four-acre lake where they shared a lovely, quiet home. However, Dr. Granville began teaching again, first at the local public schools in Tyler, and then at Texas College, a HBCU in Tyler, TX, beginning in 1985. She retired in 1988. At Texas College, she taught a newly instigated computer science course. Two years later (1990), she was recommended and invited to teach at the University of Texas in Tyler, where she was the Sam A. Lindsey Professor of mathematics, developed elementary school math enrichment programs, and retired in 1997. In addition to Dr. Granville's teaching, while on their 16 acres oasis in Texas for over 20 years, the Granville's rode their horses, raised chickens, sold eggs, and even sold the catfish they caught from the lake. After her husband Edward died in 2008, she returned to Washington, DC, in 2010, which was to be her final retirement.

Who Was the First Black Woman to Earn a PhD in Mathematics?

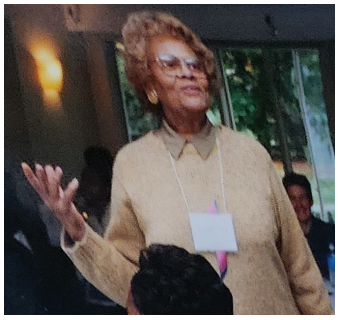

Figure 14. Dr. Granville speaking in Texas.

The author went to Texas to visit Dr. Granville to discuss with her a 50-year-old error that had been printed in the literature that Dr. Evelyn Boyd Granville was the first Black woman who earned a PhD degree in mathematics; receiving her degree from Yale University in 1949 and that Dr. Marjorie Lee Browne was the second Black woman to receive a PhD in mathematics from the University of Michigan in 1950. In 1999 the author and others learned that the first Black woman to receive a PhD in mathematics was Euphemia Lofton Haynes who received a PhD in mathematics from Catholic University in 1943. The author and others were about to put this correction in the literature. However, the author and NAM decided that this situation needed to be discussed with Dr.

Granville in person before anything was printed. It was a difficult and embarrassing conversation that had to occur in person. Even today, I do not know how so many of us articulated and printed that error for 50 years (1949–1999). In examining the official records at Catholic University and in discussing them with persons who could verify what the records stated, we had to accept as being accurate that Euphemia Lofton Haynes was the first known Black woman to receive a PhD in mathematics. The literature has now stated, for the past two decades, that the first three known Black women to earn a PhD in mathematics are

1. Euphemia Lofton Haynes, Catholic University, 1943;
2. Dr. Evelyn Boyd Granville, Yale University, 1949;
3. Marjorie Lee Browne, University of Michigan, 1950.

Figure 15. The Granville's in rural Texas.

Figure 16. Johnny Houston visits the Granville's in Texas.

Both Haynes and Granville were born and grew up in Washington, DC; both Haynes and Granville attended Smith College; both earned baccalaureate degrees in mathematics, from Smith, Haynes (1914) and Granville (1945). Haynes earned a MA degree from the University of Chicago. Neither of the first three Black women mathematicians had children. All three taught at an HBCU for some period of time. The work and archives of Dr. Haynes are housed at Catholic University. The work and archives of Dr. Granville are housed with Smith College and NAM. And the work and archives of Dr. Browne are housed at the University of Michigan and North Carolina Central University. This 50-year error or disconnect between when Haynes received her PhD degree in mathematics and when Granville received her PhD in mathematics caused the author to do several years of in-depth research to learn, as accurately as feasible, who were the first 100 Black women known to earn a PhD degree in mathematics by year. Houston is now finishing an article (with verification) of the first 100 known Black women (in less than 20 pages) who earned a PhD in mathematics. Thus, the article being written is titled "**The First 100 Black Women Known to Have Earned a PhD Degree in Mathematics, J. L. Houston List.**"

Figure 17.

Dr. Evelyn Boyd Granville has served many distinguished boards, panels, public service and professional organizations, and advisory committees before / during / after her retirements, including the Mathematical Association of America (MAA), Association of Women in Mathematics (AWM), the National Association of Mathematicians (NAM), the National Council of Teachers of Mathematics (NCTM), the American Association of University Women (ASUW), and even on the Psychology Examining Committee of the Board of Medical Examiners of the State of CA (appointed by Gov. Brown). Dr. Granville has received numerous awards and recognitions. ***The Ada Project,*** originally developed at Yale University, is designed to serve as a clearing house for information and resources related to women and computing. Given its aim and authority, it is noteworthy that **the project lists twelve women as *"pioneering women of computing."*** They are listed in this order:

1. Ada Byron King, Countess of Lovelace (1815–1852)
2. Edith Clarke (1883–1959)
3. Rosa Peter (1905–1977)
4. Grace Murray Hopper (1906–1992)
5. Alexandra Illmer Forsythe (1918–1980)
6. ***Evelyn Boyd Granville* (1924–2023)**
7. Margaret R. Fox
8. Erna Schneider Hoover
9. *Kay McNulty Mauchly Antonelli*
10. Alice Burks
11. Adele Goldstine
12. Joan Margaret Winters.

Thus, she has the distinct honor of being recognized as the first African American computer scientist, and the first African American woman computer scientist.

Dr. Granville received honorary doctorates degrees from:

1. Smith College (1989), the first African American to receive such a degree from Smith
2. Lincoln University (1999)
3. Yale University (2001)
4. Spelman College (2006)

Figure 18.

Awards she received include:

1. Wilbur Lucius Cross Medal, Yale Graduate School Alumni Association's highest honor (2000);
2. Featured in a *Yale Alumni Magazine* cover story about 150 Years of Women at Yale;
3. National Academy of Engineering honoree;
4. Inducted into the National Academy of Sciences Portrait Collection of African Americans in Science;
5. New York Outstanding Scientist Award at the same occasion where Jackie Robinson received the Man of the Year Award;
6. Dow Chemical selected her to be a Legendary Ambassador of Math for several states (2000);
7. NAM Lifetime Achievement Award (1996); and
8. NAM Golden Anniversary Legacy Award (2019).

NAM has a Lecture Series named in her honor at NAM's Annual Meeting at the JMM**: the Haynes-Granville-Browne Presentations by Recent Doctoral Recipients.** She received her 2019 award at NAM's 50th Anniversary Celebration. And she was a frequently invited honoree and/or speaker for many different occasions.

The author considered listing many of the different persons who came to know her personally and professionally and were highly impacted by her. However, many of these have passed. He does know that there are scores of persons alive today that she impressed, inspired and who view her as one of their greatest role models. Many of these are mathematicians; especially women and American minority mathematicians. In the references listed at the end of this article, one can find many more details about this amazing pioneer.

Dr. Granville shared many interesting ideas, some are listed below:

"… growing up in the thirties in Washington, DC, I was aware that segregation placed many limitations on Negroes,…However, daily one came in contact with Negroes who had made a place for themselves in society; we heard about and read about individuals whose achievements were contributing to the good of all people. These individuals, men and women, served as our role models; we looked up to them and we set our goals to be like them."

"Two of my favorite teachers at Dunbar taught me math: Ms. Mary Crumwell and Mr. Bassett."

"Among my teachers at Smith College, Mr. Neal McCoy was particularly supportive of women mathematicians, perhaps in part because his own sister was a mathematician."

"I was fascinated by the study of astronomy and at one point I toyed with the idea of switching my major to this subject. If I had known then that in the not-to-distant future the United States would launch its space program, and astronomers would be in great demand in the planning of space missions, I might have become an astronomer instead of a mathematician."

Dr. Granville also gave her views on the current problems of teaching mathematics in American schools in a lecture at Yale University:

"I believe that math is in grave danger of joining Latin, Greek, and other subjects, which were once deemed essential but are now, at least in America, regarded as relics of an obsolete, intellectual tradition."

"… (Math) must not be taught as a series of disconnected, meaningless technical procedures from dull and empty textbooks."

"We teach as if there is only one way to solve a problem, but we should let children explore various techniques… But we're not training teachers to provide this new approach."

"… children end up crippled in mathematics at an early age. Then, when they get to the college level, they are unable to handle college classes. It's tragic because almost every academic area requires some exposure to mathematics."

"Make children learn how to add, subtract, multiply, and divide, and they won't need calculators. How do you teach the beauty of mathematics, how do teach them to … solve problems, to acquaint them with various strategies of problem solving so that they can take these skills into any level of mathematics? That's the dilemma we face."

Throughout her life, she often smiled when she heard anyone say "women can't do math." In an interview with Lorentz Hall in 1994, **Dr. Granville was asked to summarize her major accomplishments. She said: "First of all, showing that women can do mathematics." She then said, "Being an African American woman, letting people know that we have brains too."**

We have lost a ***Giant*** in our communities of mathematical scientists, scholars, teachers, mentors, and advocates. She was a ***True Pioneer*** in many unchartered terrains and

Figure 19.

she inspired many to reach their highest heights. Those who knew of her, or who knew her, will always remember the footsteps that she left in the sands of time and her impact on helping America to build the most sophisticated and successful space program on this earth, and even helping America to get to the moon. She was a scholar, great teacher, great mathematician, great computer scientist, and great scientist, as well as a great inspiration and mentor for so many. The author feels very honored to have known her personally and professionally.

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Johnny L. Houston

Credits

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