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Prime Factors: America's Prioritization of Literacy over Numeracy and its Relationship to Systemic Inequity

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PRIME FACTORS:

AMERICA'S PRIORITIZATION OF LITERACY OVER NUMERACY AND ITS RELATIONSHIP TO SYSTEMIC INEQUITY

by

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ABSTRACT

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For much of American history, literacy has been prioritized in K-12 education and society, at large, at the expense of numeracy. This lack of numerical emphasis has established innumeracy as an American cultural norm that has resulted in America not producing a sufficient number of numerate citizens, and ranking poorly on mathematical performance in international comparisons. This paper investigates the decisions and circumstances that led to this under prioritization, along with the public and cultural impact of said actions. Toward this end, literature regarding contemporary and historical influences on American mathematics education (e.g., civic, policy, and parental) was reviewed. The research indicates that a general apathy from the government of the early American republic concerning mathematics education, combined with ongoing sexist, ableist, and racially insensitive practices, directly contributed to America's current predicament with numerical education. America has closed the mathematical opportunity and achievement gap from a gender standpoint, but further work must be done to accomplish the same across race and disability.

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Introduction

The impact on students of a misguided and complacent approach to fundamental mathematics education in the U.S. is evident in commentary and research from experts in education policy, parenting, mathematics education, immigration, and civil rights. From an academic and parental standpoint, reinforcing literacy skills, namely reading, writing, and mastery of language, in children at an early age, has long superseded reinforcing numeracy. Additionally, practices related to English language acquisition and use for immigrants have positioned English literacy as a defining characteristic of true Americanism. In comparison to the position that literacy holds in American culture, numeracy has long been considered more of a supplementary ability than a foundational one.

In America, there is a perception that proficiency in literacy occurs naturally, while proficiency in numeracy is perceived as either acquired or innate. Literacy is situated as a default requirement for access on almost every fundamental level in American society. Numeracy, on the contrary, is positioned as a subordinate skill—useful in many scenarios, but an aptitude one can forgo without mastering, or even acquiring basic proficiency in, and still lead a successful life. Numeracy, just like literacy, is an ability that is acquired via formal education, immersion, and practice. Where literal and numerical acquisition diverge most is in the informal interactions in everyday life that contribute to learning. Language is ubiquitous in both use and utility, while numeracy is actually also ubiquitous in use, but easy to overlook because of how deeply buried beneath the surface its uses are in everyday life.

For centuries, America has created societal, political, and educational infrastructures that minimize the general importance of numeracy in favor of literacy, with adverse consequences that span generations and impact contemporary circumstances. In the K-12 education realm, America is not producing students sufficiently competent in mathematics, with Black students particularly singled out for their supposed struggles with math. Moreover, the disabilities associated with mathematical learning are generally unknown to the masses and difficult to identify. Ultimately, if America is to remain an international superpower, it must compensate for previous policies that placed mathematics on the backburner, create circumstances that allow for equitable math learning opportunities for all students, and adjust practices in such a way that it can seamlessly adapt to the ever-changing educational landscape.

Unlike literacy acquisition, a person can easily skate by in America with limited number knowledge without raising any red flags or drawing much attention or concern. In fact, in some circles, innumeracy is worn as a badge of pride because it is a trait commonly shared in most communities. There is no feeling of inadequacy about being innumerate when the individuals in the same circles are also innumerate to varying degrees. One of the primary reasons for this is that literacy has long held more valuable cultural capital than numeracy. However, the technological boom of the 1990s, combined with the United States falling significantly behind internationally in mathematical competency rankings, led to a recent substantial domestic push towards improving national standards around numerical aptitude. Complacent for years, and primarily driven by a desire to furnish proficient American candidates to the tech sector and compete with the international employee supply, the U.S. has only recently started to broadly underscore the value of numeracy in becoming a well-rounded student and citizen.

Furthermore, American policies have created an educational landscape where not only do students, in general, struggle with mathematical fluency, but also disabilities related to math largely go unnoticed and Blacks are generally perceived to “be bad at math”. Due to a general inability of educators to recognize, diagnose, and teach students with learning disabilities in mathematics, and color-blind pedagogical practices for Black students who already have second-rate educational opportunities, two generally underserved groups get pushed even farther towards the margins, and sometimes outside of them, altogether.

To be clear, literacy is incredibly important in American society, and few would make the argument that we would be better off as an illiterate nation. As things are currently ordered, it is virtually impossible to attain any level of numeracy without some level of literacy, but the reverse is not true. One can become literate with no mastery of any numerical skills—and that is by way of design, whether intentional or incidental. Considering how reliant we are on language to communicate and how deeply embedded literacy is in our educational, social, and professional domains, there are real and significant consequences for illiteracy that position it as a key indicator of educational achievement and status. Simply put, socially, an individual will be ridiculed if it is found out that they can neither read nor write. In school, a student will almost immediately be considered a poor overall performer, by both teachers and peers, if they even struggle with literacy, and promotion to the next grade will most certainly be in jeopardy. Literacy is infused into just about every key subject area, so underdeveloped literacy skills will adversely impact a student in more than just English class and be recognized by more people. Numerical skills, on the other hand, are generally only noticed, whether good or bad, in math or science classes. Professionally, an illiterate person can get a job, but likely one with a low ceiling for promotion and limited career growth opportunities. For an innumerate job seeker, opportunities are vast, with the exception of STEM fields.

It is of interest that founding fathers like Benjamin Franklin and Thomas Jefferson considered the use of numeracy rather than religious reasons to support democratic political positions (Cohen, 1999). Mathematics has been around since ancient times, but its position as a key tool for democratic participation is a relatively new idea that emerged in the twentieth century (Moses & Cobb, 2001). As society and democracy became more numerically dependent, there arose a need to bridge the gap between the quantitative needs of citizens and the quantitative capacity of individuals (Steen, 2001).

Defining Numeracy

Not only are there multiple definitions of numeracy, but also varied interpretations of their meanings. It should be noted that the general concepts associated with numeracy have also been referred to as "quantitative literacy" and "mathematics literacy". For the purposes of this paper, the terms quantitative literacy and mathematics literacy will generally be avoided to evade confusion with the aforementioned concept of literacy, as generally defined in society. As compared to literacy, the word numeracy is a late addition to the American vernacular. In fact, it may not even be appropriate to state that numeracy is a part of the American vernacular as the term is neither widely used nor commonly understood.

Initially introduced to contrast the distinction between literate scientists and innumerate humanists, the term numeracy originated in a 1959 report on English education that compared the aforementioned groups (Cohen, 1999). Intended to be analogous to the word literacy, numeracy appeared in the *Oxford English Dictionary* in 1976 with it defined as "ability with or knowledge of numbers" (Cohen, 1999, p. 5)— a definition simultaneously simple and easily understood. A widely used definition of numerate comes from a British government report on mathematics education. In that report Cockcroft (1982) writes,

> We would wish the word numerate to imply the possession of two attributes. The first of these is an "at homeness" with numbers and an ability to make use of mathematical skills which enables an individual to cope with the practical

> demands of everyday life. The second is an ability to have some appreciation and understanding of information which is presented in mathematical terms. (p.11)

A definition of the alternative term, quantitative literacy, is "[t]he knowledge and skills required to apply arithmetic operations, either alone or sequentially, using numbers embedded in printed material" (NCES, 1993, p.3). More comprehensive definitions of numeracy come from the International Life Skills Survey (ILSS) and the Programme for International Student Assessment (PISA). The ILSS (2000) defines quantitative literacy as "[a]n aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication abilities, and problem-solving skills that people need in order to engage effectively in quantitative situations arising in life and work." PISA (2000) defines mathematics literacy as:

> An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgements and to engage in mathematics in ways that meet the needs of that individual's current and future life as a constructive, concerned, and reflective citizen.

Many commonalities exist in these definitions, however, there are also divergences and nuanced points of clarity that emerge. Overall, the definitions generally refer to instances in everyday life where matters relating to numeracy appear. In those instances, the definitions imply that a numerate individual has some level of comfortability operating and maneuvering through and around those situations. Additionally, all but one of the definitions makes mention of either skills or attributes necessary for effective engagement with numbers. It is important to note, however, that numeracy is not all about skills but also about a state of mind that, on one hand, recognizes and comprehends mathematical information, but, on the other hand, can turnkey that comprehension into appropriate application of the tools one has acquired.

Understanding and learning numerical concepts without knowing how to apply them serves little purpose—in the same way that learning how to define and spell a new word is useless if the word is used out of context. Only one of these definitions (ILSS, 2000) mentions work, and only one definition mentions appreciation (Cockcroft, 1982).

Overall, Steen et al. (2001) find that the most prominent elements of numeracy are: confidence with mathematics, cultural appreciation, interpreting data, logical thinking, making decisions, mathematics in context, number sense, practical skills, prerequisite knowledge, and symbol sense. Comfortability with mathematics makes the application of certain quantitative methods arrive as seamlessly to the mind as formulating a sentence. An individual who is comfortable with mathematics is essentially the opposite of a math anxious individual—which will be discussed elsewhere in this paper (Steen et al., 2001). Numeracy, like literacy, should be practiced intuitively in society and, ideally, its use should not trigger any recognition of application in the same way that people do not say, “I just used language” after making a statement or writing. The elements of cultural appreciation, practical skills, and making decisions help break the mental model that numeracy is applicable only to the academic setting, extending its relevance and use to situations that arise in everyday life. Mastery of these three elements empowers one to naturally identify real-life problems that are solvable with quantitative skills and apply those skills in pursuit of a solution. Prerequisite knowledge, number sense, and symbol sense are the elements of numeracy most likely to be associated with the classroom setting, which perhaps is the primary issue with K-12 math instruction.

In an ideal world, one would recognize that all the previously mentioned elements should be embedded into the numerical math environment, pedagogical philosophy, and overall curricular practices in all subjects. However, the skill-based elements are most commonly associated with formal mathematics education. Learning how to use numbers, estimate, measure, apply geometric tools, and interpret algebraic tools are all hallmarks of traditional K-12 math education. A math teacher is lucky if from their general instruction, a student demonstrates a level of cultural appreciation for mathematics beyond the curriculum. Students read literature by certain authors, become fans of their writing, and seek out additional publications by them to expand their experience with an author's work. In mathematics, every student who takes algebra I is taught the Pythagorean Theorem, but few students are familiar with Pythagoras' work beyond that theorem, as both a mathematician and philosopher. Taking an interdisciplinary approach, a history or English teacher should encourage students to use the math skills they have acquired to analyze, reason, evaluate, and make decisions in the same way students are expected to apply their language skills to all subject matters.

As will be explored in this paper, the importance of numeracy extends beyond the classroom not only in scope, but also in the impact of innumeracy on the domestic workforce—particularly in the finance, technology, and education sectors. Moreover, the goal of creating a numerate society should not exclusively be centered around measurable metrics pertaining to performance and aptitude but also a recognition of how numeracy affects so many aspects of everyday life, thereby, validating its importance. Students should not simply learn math because they are required to but, rather, they should want to because they appreciate its significance. It is also important to note the difference between the individual and collective values of numeracy present in the Cockcroft (1982) and PISA (2000) definitions, respectively—with the PISA definition aligning closely with Moses and Cobb's (2001) theories, which will be discussed later, around the importance of math in becoming a well-rounded citizen.

American Students and Mathematics Performance

With Russia's Sputnik satellite successfully making its way to space in October of 1957, the United States had essentially lost the first phase of the Space Race and, consequently, the Cold War. Critics of the American educational system attributed the failure to a focus on life skills curricula that prepare students to take on vocational professions rather than attend college or any post-secondary formal education. Reeling from the embarrassment of a public relations nightmare of being at best second to Russia from a technological standpoint and, fearing what Russia's foray into space meant from a warfare perspective, the Sputnik launch spurred the federal government to act in a manner that would bolster the nation's capacity to be an elite technological force. The result was the National Defense Education Act (NDEA), signed into law by President Dwight Eisenhower in September of 1958. As a result of this act, the U.S. saw the number of students in college from 1960-1970 increase from 3.6 million to 7.5 million students (United States Senate, n.d.). Initially, the Act contained statements referencing the conditions "which have led to an insufficient proportion of our population educated in science, mathematics, and modern language and trained in technology" (Glass, 2018, para. 8). The Act also gave loan preferences to students "with superior capacity in mathematics, science, engineering, or a modern foreign language" (Glass, 2018, para. 8). However, in 1964, Congress amended the Act to exclude both aforementioned statements that explicitly mention mathematics and engineering (Glass, 2018).

Though the U.S. started to send more students to college in the 1960s, student performance in mathematics since then has not improved much. The first international comparison of educational mathematical achievement occurred in 1967. The U.S. ranked 11th out of 12 countries evaluated that year (Barshay, 2019). Apparently, very few were surprised. Gerald

Grant of The Washington Post succinctly wrote at the time, “The poor showing of American youngsters in the first major international comparison of mathematical ability did not surprise the experts” (Grant, 1967). He further elaborated, “The experts assert that teachers here are not as well trained and that *American students nor the society at large* places much value on mathematics achievement as do many countries abroad” (Grant, 1967).

2018 results from PISA (Programme for International Student Assessment), administered internationally since 2000 to 15-year-olds globally indicates that the U.S. ranks 36th out of the 79 countries in mathematics achievement, which is below average (Barshay, 2019). In reading, on the other hand, the U.S. ranks 13th out of the 79 countries – not exceptional, but above average. Equally concerning to the current rankings is the fact that the United States has not risen in ranking since the PISA was first administered in 2000 (Barshay, 2019). Furthermore, the data indicate a severe opportunity gap not only across different schools, but within schools themselves. Top performing students at disadvantaged schools are only performing to the level of average students at wealthier schools (Barshay, 2019).

Looking at the most recent domestic math performance data, there are some interesting results to note related to racial/ethnic group cohort data compiled from the National Assessment of Educational Progress (NAEP). The NAEP is a congressionally mandated project administered by the National Center for Education Statistics (NCES) within the U.S. Department of Education that “measures students' knowledge and skills in mathematics and their ability to solve problems in mathematical and real-world contexts” (NAEP). In 2019, Black 4th graders had the lowest average score at 224— as compared to 231 for Hispanics, 249 for Whites, and 263 for Asians (NAEP). A similar trend was apparent for 8th grade students, though with wider achievement gaps. The average score for Black 8th grade students was 260—while the averages were 268 for

Hispanics, 292 for Whites, and 313 for Asians. At the high school level, there is, once again, a recurring theme of Black students performing worse on national math assessments than other races (NAEP). For the 12th grade, Black students averaged a score of 128, the lowest average score of any racial group, with Hispanics having an average score of 138, Whites 159, and Asians, 175 (NAEP). In fact, for every year for which there is data since 1990, Black 4th, 8th, and 12th grade students had the lowest average assessment score of any racial/ethnic group (NAEP). Additionally, the poor students (defined as those eligible for the National Student Lunch Program) scored lower, for all grades, as compared to students not eligible for NSLP (NAEP). For 8th and 12th grades, the only grades for which parental education level data is available, the average math assessment score increased for every additional level of education attained from the following categories: did not finish high school, graduated from high school, some education after high school, and graduated from college (NAEP). Parental influence in promoting numeracy will be discussed elsewhere in this paper, but this data does indicate some connection between a parent's level of education and their children's mathematics performance.

The History of Mathematics Education in America

The roots of America's prioritization of literacy over numeracy are directly intertwined with the founding of this nation. During America's colonial era, settlers sought to create their own identity, but also retained some traits of the English lifestyle. The use of Arabic numerals did not become commonplace in England until the middle of the sixteenth century and, by the seventeenth century, the earliest display of numeracy, arithmetic, was primarily used for commercial, rather than educational purposes (Cohen, 1999). Prior to the introduction of Arabic numerals into English society, Roman numerals were used most prominently. However, Roman numerals only allowed the expression of quantities and not any manipulation or calculation (Bunt et al., 1988). For the purposes of being numerate, Roman numerals were, for all intents and purposes, essentially literal expressions of values mainly utilized for record-keeping.

Even after the English settled in America, there was almost no application of numerical practices that existed outside of economic purposes. In fact, during the seventeenth century, south of New England, most settlers were both innumerate and illiterate while, on the other end of the spectrum, Puritan settlers in New England, and Massachusetts, specifically, arrived to America with the highest rates of literacy and university degree attainment of any migratory group. Although they established grammar schools for their children, as well as Harvard College, arithmetic was not one of the subjects deemed important for their children, whom they intended to become ministers, rather than merchants or scientists (Cohen, 1999). In fact, in the charter for a school in New Haven, it was explicitly mentioned that the school was to teach pupils how to read, spell, and write but specifically not learn numeration or addition (Tyack, 1967).

Eventually, by the eighteenth century, a need arose for individuals with numerical talents to fulfill several vocational tasks. Among the most popular careers that required quantitative abilities at the time were cartographers, surveyors, and navigators—who were considered mathematicians and would perform tasks on behalf of local colonial governments (Cohen, 1999). In the late seventeenth century, approximately one hundred years prior to the American Revolution, there were only 134 instrument-makers and about three dozen individuals who taught the mathematics of navigation and surveying (Bedini, 1975). Though the need for highly numerate professionals had increased by the eighteenth century, the education realm had not caught up to the demand of producing numerate students. Even in New England, which was home to the most extensive public school system in America at the time, arithmetic was still not taught in a typical school curriculum because it was considered too difficult for students under the age 12 to learn. This made mastering numerical skills even more complicated as it was not common for students older than 12 to even continue their schooling. In the event that young men decided they wanted to learn arithmetic, they would have to ask their schoolmaster to provide extracurricular evening classes so as to not interfere with the daily school schedule, or enlist the services of a private tutor (Cohen, 1999).

By the mid to late eighteenth century, there was finally a broader recognition among both scholars and political leaders that there was some value to arithmetic instruction that surpassed strictly commercial purposes. Following the American Revolution, the newly organized republican government of America had to determine what values were important to its citizenry. As such, arithmetic became widely acknowledged as not just a specialized skill but, rather, an essential one that should be incorporated into grade school curriculum as a required subject. In a 1788 letter to Nicolas Pike, the author of the first American arithmetic text of the new republic, George Washington wrote, "The science of figures, to a certain degree, is not only indispensably requisite in every walk of civilised [*sic*] life, but the investigation of mathematical truths accustoms the mind to method and correctness in reasoning, and is an employ [*sic*], peculiarly worth of rational beings" (Cohen, 1999, p.132). At this point, arithmetic was recognized as not demonstrating practical utility but, as an academic endeavor. It became firmly accepted as a means to exercise the mind, and allow individuals to think more rationally, logically, and reasonably.

In the early years of numerical education, during which mathematic curriculum primarily centered around arithmetic, educators initially found it difficult to draw clear lines between numeracy and literacy. As the practice of mental math had not yet become commonplace, and the use of Arabic numerals was still a fairly new phenomenon, for many, representing numbers as words was the easiest way to make sense of arithmetic. Ultimately, there was a push to learn arithmetic operations from memory and number recognition rather than using mnemonic tricks, numerical rules, or first translating numbers into words, and then back to numbers for a solution (Cohen, 1999). For instance, a well-trained student would see 2 + 3 and automatically know the answer is 5 rather than stating either mentally or verbally, "two plus three equals five."

Women in Mathematics During the Early Republic

If, during the seventeenth and eighteenth centuries, a numerical focus for the general American population was considered to be limited, then for women it was nearly non-existent due to blatant sexism. In the 1820s, female students were first introduced to arithmetic, though not without educators needing to justify why females needed to learn it as female schools at the time taught only reading, writing, and the ornamental arts (Cohen, 1999). Common thinking in those days was that arithmetic was not ideal to be taught to females, but it was considered acceptable for girls to learn the four rules: addition, subtraction, multiplication, and division. Beyond learning arithmetic, girls were thought to have insufficient mental capacity to handle the reasoning and logical aspects of mathematics. Even in circles where females were considered to have equal capacity to learn as males, learning mathematics was never a priority because no one thought women needed mathematical skills. Mathematics was primarily used for commerce and bookkeeping—fields that even few men were involved with, and essentially no women (Cohen, 1999). Considering women were the primary caretakers of children and spent the most time with them at home, it would be nearly impossible for mothers to support their children's mathematical learning at home because they had not been educated in mathematics. This fact, combined with the lack of protracted mathematics education for male students aged 12 and above, had America trending towards several generations of mostly innumerate males, and fully innumerate females.

The initial rationale for educating girls in arithmetic was so that if they eventually became wives, they would be able to appropriately manage household accounts and records of bills without driving the household into debt (Burton, 1970). In the 1790s, at the Young Ladies' Academy of Philadelphia, the first post-revolution female academy, arithmetic education was once again exclusively justified as a measure to support future male partners in accounting and budgeting (Cohen, 1999). In framing mathematics education for women as something that could be beneficial for men, American society saw no threat to the dominant male status with women learning arithmetic. From an academic standpoint, the gender boundaries that existed to propel men into a higher educational tier were still firmly entrenched—at least to the extent that female math education did not exceed arithmetic. In the nineteenth century, as America became more domestic, educators further pushed the boundaries of what type of math education for women would be acceptable. The more advanced branches of mathematics like algebra, geometry, trigonometry, which all require deeper levels of quantitative reasoning, served no purpose in what were expected to be the domestic lives of females of that era. Geometry, in particular, with its focus on theorems used to craft proofs, was considered among the least feminine aspects of mathematics as it was less mechanical and memory-based and more rationality-based (Webster, 1959).

Female educators like Emma Willard worked through the 1820s to expand the curriculum of female academies and teach them more than just simple computation. The New York state government, which was controlled by men, was so threatened by the fact that Willard's Troy Seminary was teaching female students geometry, trigonometry, and conic sections that it considered revoking funding for the school (Lutz, 1964). The lack of proper mathematics education for girls in the early republic was not only instrumental in setting back the numerical advancement of females, but the nation, overall. As a result, approximately half of the American population was largely innumerate for most of the eighteenth and nineteenth centuries. Interestingly, as women started to dominate the teaching workforce, as they provided cheaper labor than men, it became necessary for women to become numerate so they could teach the future generations of students. The sexist approach of not numerically educating females backfired twofold as the teacher ranks were eventually filled with female teachers who had not received adequate mathematical learnings, and the need to supply a satisfactory number of math teachers made it absolutely necessary to ensure there was a pipeline of sufficiently educated females in the workforce (Bernard & Vinovskis, 1977).

The impact of early republic-era policies around math education for females created problems centuries later. Even though females tend to have equal or higher scores than males on mathematics assessments and course completion in high school, they enter science and mathematics fields at much lower levels than males (Shettle et al., 2007). There is a stark contrast between women in science and math fields as compared to the humanities where female students comprise approximately 18% of college engineering students, but 64% of humanities students (Wang & Degol, 2017). In society, it is expected that active participants, if they are to be relevant or contributors, be, at a minimum, literate. However, American society does not have the same expectation around numeracy—particularly as it relates to women (Hill et al., 2010). Many Americans find it perfectly acceptable for a woman to be innumerate, and for a significant portion of American history, it was actually encouraged.

Math Course Taking Over Time

By the time the 20th century arrived, it was clear the having a numerate society would be beneficial to that society's residents, but America struggled with enrolling a sufficient number of high school students into corresponding higher-level math classes. Over the first half of the 20th century, even as the number of students in schools ballooned with a growing population, both the number and percentage of students taking high school mathematics courses in algebra, geometry, and trigonometry (a traditional math sequence) decreased. In the 1909-1910 school year, 56.9% of high school students reached algebra as their highest level while 30.9% reached geometry, and just 1.9% reached trigonometry (Coxford, 1970). Just over ten years later, the 1921-1922 school year reflected numbers for the most advanced high school math class taken had dropped even lower to 40.2% for algebra, 22.7% for geometry, and 1.5% for trigonometry (Coxford, 1970). By the end of the 1952-1953 school year, the enrollment numbers in high school math courses had fallen precipitously to just 24.6% for algebra, 11.6% for geometry, and 1.7% for trigonometry (Coxford, 1970). By the mid-20th century, America had reached a point where high school math education did not appear to be a priority at all, and the majority of students who graduated from high school had not even been enrolled in a high-school level math class. Considering that level of enrollment does not even speak to the level of achievement, American high school students were headed towards a dangerously innumerate territory. Then, in 1957, the Russian Sputnik satellite made it into space and forced America to re-evaluate its educational priorities if it planned on remaining the pre-eminent international superpower.

High school course taking and credit earning data from 1982, 1992, and 2004, collected by the NCES in three different studies from the transcripts of high school students, show that America was mostly able to course correct and reverse the very troubling trend of decreasing advanced high school math enrollment and completion. The tendency to enroll students in academically rigorous courses—in this case mathematics courses—often refers to what is called the inclusiveness of a school (Sorenson, 1970). In 1982, 49% of high school graduates took either algebra I or algebra II, which are the two earliest courses in the math sequence, as their highest math course, with 31% taking the former and 18% taking the latter (Dalton et al., 2007). Similarly, in 1992, once again, 49% of graduates completed either algebra I or algebra II. By 2004, that number dropped to 44% for those two courses, however, the split between algebra I and algebra II shifted, with 18% of students completing algebra I and 26% of students completing algebra II (Dalton et al., 2007) .

Not surprisingly. this shift to more advanced math completion continued from algebra II to geometry, trigonometry, precalculus, and calculus—where completion rates for all of these courses increased from 1982 to 1992, and again from 1992 to 2004. For the top four course levels, from 1982 to 2004, the combined completion rates of all four courses increased from 45% to 77% (Dalton et al., 2007). Additionally, between 1982 and 2004, there was a 20 percentage point decrease, from 25% to 5% of students who either took a low academic math course or no math course at all (Dalton et al., 2007). By and large, it is clear that American schools have improved the mathematical offerings and completion rates of math courses since the launch of the Sputnik. The reality is, there was no other option, but the question remains as to whether the adjustments were too late, and whether there will be any additional improvement. The average number of math credits earned increased from 2.7 in 1982 to 3.6 in 2004, but one is left to wonder how close America is to approaching a ceiling as growth slowed between 1992 and 2004 to an increase of .3 credits as compared to a .6 credit increase from 1982 to 1992.

The disparities in performance between Black and White students may end at the assessments, but they start with math course taking and the opportunities, with respect to access and quality, that are often afforded to White students and not Blacks. Though, overall, Black students increased their math course taking and completion from 1982 to 2004, at a 19% completion rate, they still lag behind Asians (57%), Whites (37%), and Hispanics (22%) in the percentage of students who have completed precalculus and calculus by the time they graduate (Dalton et al., 2007). The lower completion rates among Black students for advanced math courses is significant as it relates to long-term numerical proficiency because it has been shown that students who take precalculus, even if they have mediocre grades, are more likely to receive bachelor's degrees in STEM fields than students who only complete up to algebra II (Adelman, 1998).

Though placement in advanced math classes should be meritocratic, oftentimes the process for enrolling students in classes involves personnel influence, which then becomes susceptible to implicit biases or racism. Track placements are largely determined by measures like grades and test scores, but the influences of teacher recommendations, parents, and guidance counselors present subjective criteria that are used in the decision-making process (Kelly, 2009). There is evidence that statistical discrimination exists among school personnel that favors high-status groups and, thus, reinforces the prioritization of White students over Black students for track placements (Kelly, 2009). Furthermore, as there is evidence teachers perceive Black student put forth less effort in their schoolwork, there are multiple instances where bias can adversely impact Black students' ability to take advanced-level mathematics courses (Ainsworth-Darnell & Downey, 1998). Kelly (2009) showed that in predominantly White schools, Black students are at a clear course-taking disadvantage and that disadvantage gradually disappears as a school becomes more integrated.

Gamoran (1987) found that there is a high-track effect in mathematics, where high-track students showed gains of about 2.5 times that of low-track students over a two-year period. The "opportunity hoarding", or inequality based on membership of a racial group, serves to widen the opportunity gap at schools as White students hold a disproportionate number of seats in advanced math classes and relegate Black students to low-track trajectories (Tilly, 1999). Track placement is a significant factor in the success of Black students in mathematics as it has been shown that upward mobility in mathematics is very difficult after sophomore year (Lucas, 1999). Ultimately, in most instances, by the time a student is a sophomore in high school, the ceiling of their math attainment is already established and almost pre-determined. For example, a student who has not completed algebra II by the time they finish freshman year (or at worst, sophomore year if they plan to double up with classes) will never even have the opportunity to take calculus before they graduate. This limits the opportunities Black students have to take non-remedial college-level mathematics courses as they often have neither taken nor passed the high school prerequisites that track them towards higher-level mathematics.

The relegation of numerical skills to the back burner does not stop at the end of secondary education. College faculty in the natural and social sciences tend to express concern about deficiencies in both the communication and quantitative skills of their college students, while faculty in the humanities and social sciences generally seem concerned with only communication skills (Ewell, 2001). Furthermore, that concern may be related to the extent to which numerical or literal shortcomings negatively impact a student's ability to be successful in a course rather than a recognition of the importance of mastering those skills from a societal standpoint. In fact, it would likely be very difficult for professors in the social sciences, and more so the humanities, to even recognize quantitative shortfalls as the curricula in those fields do not typically have much embedded numerical content. How often do numerical questions arise in a literature, history, or foreign language coursework? In contrast, a mathematician or scientist must still be literate to master their content area.

The American Legacy of Prioritizing Literacy over Numeracy

In his analysis of the immigration to the United States through Ellis Island at the turn of the twentieth century, Jay Dolmage reinforces the idea that literacy is, and has been, more strongly supported in American society than numeracy. Discussing the creation of terms such as "feeble-minded" to describe individuals thought to be intellectually less capable, and "moron", "imbecile", and "idiot" to denote degrees of intellectual incapability, Dolmage (2018) writes, "[a] regime of literacy and IQ testing, but also a regime of vision, was responsible for the solidification of these terms..." (p. 75). He later states, "the Commission focused on skin color; on "psychic disposition"; on head measurements; and on not just language but also perception of literacy" (Dolmage, 2018, p. 85). There are no references to evaluating the numerical aptitude of immigrants, specifically, which underscores that for quite some time in American society, English language mastery was considered to be the most important educational attribute.

It was not just literacy that was emphasized by the gatekeepers to America but, more specifically, English literacy. This focus on English literacy was the result of xenophobic—and intolerant—fears that immigrants speaking their native languages would set back an American culture that was firmly grounded in Anglo-Saxon ideals and practices. Though not the official language of the U.S., English is ubiquitous in America, and synonymous with America internationally. Additionally, from a social, cultural, and academic standpoint, language serves as one of the more obvious and tangible markers of cultural differentiation that can either allow someone the blend in effortlessly or stick out like a sore thumb (Alba & Nee, 2003). As such, true assimilation into American culture requires significant proficiency in the English language and commensurate literacy competence. Furthermore, English language mastery serves as a proxy for Americanism culturally, and as a proxy for intelligence and talent in educational and professional settings, respectively.

President Franklin Delano Roosevelt, who benefited greatly from immigrant votes at the polls, was quoted in 1924 as saying, “Looking to the future, they wisely choose that their children shall live in the new language and in the new customs of these new people. And those children more and more realize their common destiny in America” (Fleegler, 2013, p. 36). Later, in a 1950 Senate investigation of America’s immigration laws, spurred by concerns about the nation’s approach to immigration, a report by a subcommittee of the Senate Judiciary Committee stated, in reference to the foreign-language press, “Its very existence tends to preserve the alien language of the immigrant and to sustain nationalist and particularist [*sic*] tendencies, and may even create antipathy toward the American way of life” (Fleegler, 2013, p. 110). In the twentieth century, the emphasis of English language acquisition and mastery by first-generation immigrants trickled down to their future generations as first-generation parents are reluctant to have their children participate in bilingual education programs, and promote mastery of the dominant host language—in America’s case, English.

A 2000 poll of Americans found that 75% agreed with the statement “speaking English as the common national language is what unites all Americans” (Alba & Nee, 2003). If the overwhelming majority of the population feels that common language is the great unifier, then it behooves those who emigrate to America to prioritize learning English. In this instance, there is a significant difference between a skill being beneficial and a skill being absolutely necessary. Oftentimes, those who seek success in American culture do not even recognize that they are assimilating but it is obvious to them that insufficient literacy in English by immigrants is perceived to hold adverse consequences from a social and economic perspective (Alba and Nee, 2003). Without a firm grasp on English literacy, one’s social circles are limited to those who speak a common native language, and employment opportunities are almost non-existent. Additionally, to even become a U.S. citizen, an applicant must demonstrate sufficient educational requirements, however, those requirements only include English language and civics proficiency. The English language section evaluates an applicant's ability to read, write, speak, and understand English while the civics portion tests an applicant's understanding of U.S. history and government (U.S. Citizenship and Immigration Services, 2021). There is no mathematical competence requirement, whatsoever. The naturalization process promotes the impression that a U.S. citizen must be literate but can be innumerate without the government caring.

The Relationship of Mathematics to Civic Participation

To be a participant in the modern economic ecosystem, full participation in the civic process depends on skills like number sense, estimation, problem solving, and quantitative reasoning, in the same way voting rights did during the civil rights movement (Moses & Cobb, 2001). With his colleague, Charles Cobb, Moses thoroughly analyzes the civil rights movement, his efforts to educate middle and high school students in poor neighborhoods and the intersection of those two convergent paths. While in Mississippi leading the Freedom Summer, Moses had two revelations that prompted his focus on math literacy. By the time he had ventured down South in 1964, a technological innovation first used on a plantation in Hopson, Mississippi in 1944 – a cotton-picking machine that could harvest bales of cotton at an incredibly fast pace, disentangled the financial codependence that existed between White farmers and Black sharecroppers. Equipped with the technology to harvest cotton without the need for a labor force, White farmers no longer relied on Black slave descendants to work their fields (Moses & Cobb, 2001). Similarly, in 1943, the U.S. Army contracted engineers to create a machine to calculate artillery firing tables. That machine, called the Electronic Numerical Integrator and Computer (ENIAC) was the world's first programmable computer. The two discoveries illuminated to Moses the power of technology and mathematics to create pathways to freedom, efficiency, and exploration.

Moses and Cobb make very clear the relationship between their work to advance mathematics literacy and how that initiative intersects with race in America. Racism arose as a means for social and economic control and dominance, and "racism involves material conditions, power, legal status, and privilege, as well as prejudice" (Thompson, 1999, p. 143). After slavery was abolished, literacy was used as a tool to oppress free Blacks and was a key obstacle in preventing blacks from fully participating in American democracy. In the deep South, where formal education was rare for Blacks, literacy tests were used by voting registrars to determine eligibility to vote and, as many Blacks in the South were illiterate, they were denied that right (Moses & Cobb, 2001). For example, in Mississippi, illiterate Whites were given one-sentence passages of the Mississippi Constitution to write and copy while Blacks were given long, complex, and dense passages to complete the same fulfillment. The denial of the right to vote essentially deprived Blacks of true citizenship and relegated them to the whims of the majority. In the same way literacy was the barrier to legitimate citizenship then, numeracy, with its increased prominence in recent decades, is the gateway to citizenship now. Considering his experiences on the front lines of the civil rights movement, Moses wholly understands the impact on marginalized groups of living in a society where individuals, for all intents and purposes, have been disenfranchised and removed from impacting the civil and legal systems that are oftentimes reflexively used to oppress them.

The arrival of the computer would gradually push the U.S. away from industrial tech jobs and towards computer tech jobs (Moses & Cobb, 2001). Observing the importance of technology and being prescient enough to foresee the long-term significance of the computer in society, in the 1980s, Moses observed that "…while the visible manifestation of the technological shift is the computer, the hidden culture of computers is math" (Moses & Cobb, 2001, p. 13). Of particular note is that the culture – in this case, mathematics – is not visible, but manifested. Over 40 years ago, Moses saw that the future world would be driven by technology – a domain that sits atop an oftentimes underappreciated culture of mathematics, however, he recognized that in the pedagogical world at that time, there was still more of an emphasis on literacy. Hence the creation of the Algebra Project, which unlike Moses' work registering voters in a limited area of

Mississippi, is an initiative that is needed on a broad-reaching national level.

Despite the recent acknowledgment of its importance, there are several misconceptions about mathematics that make its study generally unappealing. John Allen Paulos, a mathematics professor, identified the misconceptions as: mathematics is nothing more than computation, math is a hierarchical subject, storytelling is not an effective educational tool for mathematics, math is only for the few, and math limits our freedom (Paulos, 1988). By the time students get to college, being competent in mathematics is looked upon as a skill, talent, or innate gift that only certain people possess, while being literate is conventional and expected. A college student who can neither read nor write well is judged more harshly than a student with limited mathematical ability. After all, there is an expectation that literacy skills are used every day and under almost all circumstances. An innumerate college student can take a remedial math course and fulfill their math requirement for graduation, and simply avoid number-dense subjects on their way to a degree. In these instances, numeracy has presented an obstacle that can be easily circumvented. Conversely, an illiterate student is unlikely to graduate from an American college at all. Literacy and mastery of language are so deeply embedded into so many academic disciplines, in ways that numeracy is not, that an illiterate student's weaknesses would be exposed almost immediately.

Additionally, studying mathematics in higher education is generally considered a means to an employment end specifically tailored around quantitative skills, and students who do not plan to enter fields such as engineering, finance, or actuarial work are generally not encouraged to take higher order math classes as they are considered to serve little to no purpose in the student's future. On the contrary, students are not advised to forgo English and literature courses simply because they do not plan to become journalists or novelists (Paulos, 1988). As Moses and Cobb (2001) state, "Forty percent of students taking freshman calculus in U.S. universities fail it;

but not being “good” in math does not in any way imply inferiority, rather, it confirms that you’re just like most everyone else” (p.10). Moreover, Americans often take pride in mathematical incapacity because the consequences of innumeracy tend to be less obvious than those of illiteracy (Paulos, 1988). The markers of innumeracy are so subtle that they are not generally perceptible in everyday casual encounters and are typically only illuminated in an academic setting.

Parental Influence on Numeracy

Whereas it is common for a parent to keenly observe and correct their children as they read aloud or write an essay for class, it is rarer the occasion that a parent takes it upon themselves to help their children with algebra homework. Cannon and Ginsburg (2008) showed that parents feel schools are primarily responsible for math education and, in turn, perceive their role in their children's math achievement to be less important than their role in the achievement of other subjects like reading. Moreover, in a study comparing parents' early approaches to mathematics and language, compared to language, parents reported math was taught less frequently at home, should be emphasized less in preschool, required more direct instruction, and was less of a personal interest and strength (Cannon & Ginsburg, 2008). Particularly for math, the academic socialization of parents, which is influenced by factors like parents' own feelings and experiences with math, along with values, beliefs, and expectations parents have around their children's academic performance, can explain the variability in educational achievement and the generally negative attitudes children have towards math (Cannon & Ginsburg, 2008).

In a study examining parental expectations of preschool children around math performance as compared to language and social skills, and how much influence parents feel they have over preschoolers acquiring math skills as compared to other developmental areas, social skills, general comprehension, and reading were considered by parents to be the most important skills to acquire for first grade success (Musun-Miller & Blevins-Knabe, 1998). Stated more plainly, parents felt it was more important for their preschool-aged children to acquire general information about the world and interact well with others than acquire math skills (Musun-Miller & Blevins-Knabe, 1998). Interestingly, considering the low level of importance parents placed acquiring math skills, parents perceived themselves to have more influence on the development of math skills than any other factor – contradicting the popular belief that math skills are inherent (Musun-Miller & Blevins-Knabe, 1998). This contradiction, in turn, creates a dynamic where parents recognize they can influence math skill acquisition at an early age but do not because they have underprioritized it, or lack the skill to support in any meaningful way.

Studies have shown that the home numeracy environment, which accounts for parent-child engagement in numeracy-related activities, has a direct relation to numeracy skills and math language knowledge (King & Purpura, 2020). Hence, parents must be both knowledgeable enough and willing to create a home numeracy environment that embeds sufficient exposure to math language that will lead to numeracy development, as early math vocabulary knowledge is significantly predictive of later math achievement (King & Purpura, 2020). Before a child ever sets foot in a classroom and meets their first teachers, they have learned just about everything they know from their parents, and often informally. Education does not start in pre-school or kindergarten, but rather in the home – with parents serving as the instructors. Prior to starting formal education, children spend the majority of their time in their households around, and learning from, their parents. As such, it is the responsibility of parents to develop children's early math foundational skills – even if the concepts at that age may seem simple. However, most parents of preschool-aged children believe schools are primarily responsible for mathematics skills, overestimate their children's numerical knowledge, and express uncertainty about early mathematics teaching and learning (Evans et al., 2004; Fluck et al., 2005). Research has also shown that parents overwhelmingly prefer to teach their children language over mathematics, think language can help children accomplish more in school, and that they must intentionally work to make teaching math enjoyable (Cannon & Ginsburg, 2008).

King and Purpura (2020) examine how the home numeracy environment (HNE) and math language knowledge in children aged 3-5 impact a child's ability to later acquire numeracy skills – underscoring the importance of effective parent intervention and education around math for children early on. The HNE considers the frequency of direct numeracy activities and indirect numeracy activities between a parent and a child, while math language is defined as "content-specific language that consists of terms used to describe quantitative and spatial relations but does not include direct references to specific numbers" (King & Purpura, 2020, p. 253). More specifically, King and Purpura's research investigates the relationship between content-specific math language and early numeracy skills. Parent-child engagement in both direct and indirect numeracy activities were studied to determine the most effective ways to infuse math language in the home environment. The authors suggest two theories: "math language may casually underlie numeracy development and children's numeracy skills are highly language-dependent" (King & Purpura, 2020, p. 253). In this study, 125 preschoolers were assessed on early numeracy (set comparison, number comparison, number order…), math language (most, more, fewest, less…), and general language. The results suggest that "…the direct home numeracy environment is associated with both numeracy skills and math language knowledge, and that math knowledge may be a mechanism that explains the relationship between the direct home numeracy environment and early numeracy" (King & Purpura, 2020, p. 256).

Many parents do not realize the importance of their behaviors on their children's mathematical development. Gunderson and Levine (2011) explore the extent to which parent number talk impacts children's cardinal number knowledge. More specifically, the authors analyze a major milestone in mathematical development, the cardinal principle, which is when a child can recognize that for sets larger than 4, the last number reached represents the count of the objects (Gelman & Gallistel, 1978). Their research notes that by the age of 4, there can already be a 1-2-year age gap between children who are mathematically advanced and those who are not (Gunderson & Levine, 2011). This finding underscores the importance of parents establishing a functional home numeracy environment as early as possible to mitigate any gaps before children start formal schooling.

As a result, Gunderson and Levine (2011) examine the relationship between early home environment interactions between parents and children, and how they influence mathematical development. Considering most young children who can count to 10 are often unable associate their count with a set size, the authors focus on two concepts: does number talk that references present objects better predict future number knowledge than number talk that does not, and what role does number talk of small sets (1-3) and large sets (4-10) play in predicting children's number knowledge. In this study, the examiners observed parents on whether they were counting or labelling a set when describing it, and whether the set was small (1-3) or large (4-10). It is important to note that the authors have identified that small number talk, important to learning the meanings of the words 1, 2, and 3, are common among parents while large number talk, of sets size 4-10, is rare among parents (Gunderson & Levine, 2011). The authors found that not all varieties of parent number talk are important for promoting number knowledge as number talk directly related to labeling perceptually present objects is more related to cardinal number knowledge than number talk that does not. Additionally, parent number talk related to sets of size 4-10 is the strongest predictor of children's later cardinal number knowledge (Gunderson & Levine, 2011). These findings suggest that while large scale number talk is most predictive of meeting the key numerical benchmark of cardinal number knowledge, it is also rarer and, hence, parents are incidentally setting their children up to be insufficiently numerically prepared in that regard.

Ultimately, there are three primary issues when it comes to early parental influence on numeracy: the willingness of parents to create a home numeracy environment that promotes parent number talk, whether parents know what aspects of numeracy to focus on prior to their children entering school, and parent comfortability with teaching numerical concepts to their children. Overall, parent involvement in homework help for their children has a positive impact on academic achievement, however, this is truer for verbal subject matter than it is for mathematics (Robinson, 2014). The adverse impacts of parental math intervention for children are particularly apparent for parents who suffer from math anxiety. Ashcraft (2002) defines math anxiety as “a feeling of tension, apprehension, or fear that interferes with math performance” (p. 181).

The Influence of Math Anxiety

For college-aged adults with math anxiety, simple elementary arithmetic computations like “24 – 7”, become complicated, confusing, and stress-inducing endeavors – even though the individuals have learned the arithmetic and understand the underlying concepts. It should be noted, however, that there is no evidence math anxiety is caused by poor math performance, and work to enhance mathematical competence does not decrease math anxiety (Hembree, 1990). A significant consequence of math anxiety is math avoidance. Math avoidance can ultimately lead to math anxious individuals taking fewer elective math courses in high school and college, and lead to lower grades in those courses when they take them, as compared individuals with low levels of math anxiety (Ashcraft, 2002). The connections between math anxiety and college course taking are displayed by the levels of math anxiety associated with students in different college courses and of different majors. Coincidentally, the highest levels of math anxiety are associated with the least rigorous college math classes. Hembree (1990) found that, from a coursework standpoint, the highest levels of math anxiety were found in students taking math for elementary school teachers and developmental math—followed by students taking remedial algebra, and college algebra. This trend makes sense, as for elementary math education, the stakes are high as poor performance in the class is determining factor for career progression. Remedial and entry level classes are often required for students who do not demonstrate acceptable levels of math performance by the time they reach college so, once again, it is not surprising to see high levels of math anxiety with these courses.

On the college major front, the highest levels of math anxiety were found in students majoring in elementary education—followed by humanities and social science majors (Hembree, 1990). Naturally, students who are taking remedial or developmental math courses in college were likely not high performers in math in high school so high levels of math anxiety in those courses seems justified. It is possible that a math anxious student is in a remedial course because of how their anxiety has affected their math performance up to that point, and also possible that the pressure of the remedial course induces a higher level of anxiety. Considering the role remedial courses play on college campuses of ensuring students demonstrate proficiency in key academic subject areas, the pressure of passing a remedial math course is daunting to students who know they need that credit to graduate. After all, a student would not even end up in developmental or remedial math if they, through some other means like high school math performance or scores on remedial exams, demonstrated they did not need to be in the class in the first place.

Very concerning, and perhaps more surprising, are the levels of math anxiety found among future elementary school teachers. If the educators of America's future generation of mathematicians are anxious about their college-level math courses, that has to bring concerns around not only their mastery of the subject matter, but also how their anxiety is transferred to their classroom setting and through their instructional practices. There is also a strong negative correlation between math anxiety and motivation and self confidence in math with the correlations ranging from -.47 to -.82 (Ashcraft, 2002). The ramifications of such math anxieties extend beyond secondary and post-secondary education as math anxious individuals tend to avoid quantitative and heavily math-dependent college concentrations and paths, which close off a significant portion of job opportunities (Ashcraft, 2002). Ultimately this aversion to math will inevitably lead to limited participation in mathematics and exclude math anxious individual from full participation in the civic and economic process (Moses & Cobb, 2001).

Mathematics and Race

When students finally do reach the classroom, they are at the mercy of a K-12 math education system that has not been able to maintain any consistency due to conflicts regarding the theory underpinning the instructional approach. On one end of the conflict in the “math wars” are the members of the mathematics community – which includes not only math professors, but also teachers, who take a more fundamental approach that emphasizes basic skills mastery along with learning larger concepts (Garelick, 2016). On the other end of the spectrum are the educationists who prefer a style of new or reform math that prioritizes discovery learning over drills and procedures. With the data from traditional math instruction indicating low levels of proficiency by American students, many school districts, with support from the Federal government, opted to implement the reform math, however, even using new curriculum and textbooks, student results have not improved (Garelick, 2016). Bonilla-Silva (2010) identifies four key frames that allow racism to perpetuate in subtle manners: naturalization, cultural racism, minimization of racism, and abstract liberalism. As a result, Black students, must also contend with the inequities that are created by instructional strategies that employ a color-evasive approach that does not consider race and culture in mathematics education.

With subjects like English, history, art, and music, it is relatively easy for teachers to reference contributors to those genres from just about all races, including Blacks. But for mathematics, on the other hand, off-hand references to prominent Black mathematicians are essentially non-existent. Consequently, it can be difficult for educators to connect the impact of Black exemplars of excellence in mathematics, to the students whom they teach. Writers like Maya Angelou and James Baldwin are prominently featured in English curricula, and Black students recognize and appreciate their contributions to literature. One would be hard-pressed to find any student unaware of the impact Malcolm X and Martin Luther King, Jr. had on the civil rights movement, and their standing in American history. In the art world, individuals like Jean-

Michel Basquiat and Gordon Parks are examples of Blacks who thrived in the art world and rose to prominence. With mathematics, educators struggle to infuse references to, and contributions of, Black mathematicians to the field because there are so few Black mathematicians of prominence. Though it starts in the K-12 classrooms, the impact of a dearth of Black mathematicians extends to both career prospects in math-related fields, and graduate school opportunities. In 2019, of the 2,013 PhDs awarded in mathematics in the United States that year, only 32 (1.6%) of them were awarded to Blacks (National Center for Science and Engineering Statistics, 2020).

QuantCrit is a framework created by Gillborn et al. (2017) that aims to dispel the common notion that quantitative matters, including in education and research, are racially neutral. Society has come to associate quantitative metrics as objective and foolproof, as compared to qualitative observations, as if racism and discrimination cannot penetrate numbers. Qualitive observations are deemed more susceptible to biases and leave more room for debate as they often cannot be proven. As such, quantitative data, if used incorrectly, can actually be more detrimental than qualitative data in furthering racist ideologies due to how unbiased it is perceived to be by society. In a sense, the numbers, themselves, are neutral, however they are used and applied by humans—which makes them susceptible to the same concerns that arise when using qualitative data. Among the principles of QuantCrit that closely align with the themes explored in this paper are: "numbers are not neutral and should be interrogated for their role in promoting deficit analyses that serve White racial interests; voice and insight are vital: data cannot 'speak for itself' and critical analyses should be informed by the experiential knowledge of marginalized groups; statistical analyses have no inherent value but can play a role in struggles for social justice" (Gillborn et al., 2017, p. 158).

Historical data regarding math achievement by Blacks is used to normalize low math performance and temper expectations around progress. In some ways, the quantitative data is used as an out by school leaders and teachers who oftentimes fail to acknowledge the practices and realities that lead to Black students performing poorly in math. Ultimately, the achievement data create a narrative about the inability of Black students to persist and sustain in STEM fields when, in fact, the STEM fields have failed to adequately support Black student achievement (McGee & Spencer, 2015). Normalizing lower achievement, in turn, creates an educational ecology that erases accountability for the math educators of Black students. As a result, success in math by Black students is seen more as an aberration or surprise than the expectation. Furthermore, success by black students in math, and representation in the STEM sector that exceeds averages or traditional rates is looked at as an overachievement rather than simply an achievement. Naturally, these deficit perspectives permeate the classroom setting and create an environment where not only teachers expect Black students to fail, but students and families do as well. QuantCrit understands and foregrounds the experiential knowledge of people of color and other marginalized groups in a world where numbers are often used to speak to the interests of Whites (Gillborn et al., 2017).

The QuantCrit framework helps illuminate how the data that is used, viewed, and analyzed on a daily basis is highly White-centered, thereby hiding the presence of racism within education. Numbers are regularly used to promote deficit perspectives and remove racism by applying tools, models, and methods that do not consider racism as a factor in daily life (Gillborn et al., 2017). It is easy to simply look at data and conclude that Black students are less skilled at mathematics if one does not peel back the layers of institutional oppression that situate Black families, and their children, at the bottom of the totem pole academically, economically, socially, and professionally. The low performance numbers, that are largely a result of institutional practices, are then weaponized against Black families, in insensitive manners that are unproductive to academic success, placing the blame almost solely on the parents for why Black students have lower math performance outcomes.

The Impact of White-Centeredness upon Black Math Students

In addition to the concern regarding creating a sufficient home numeracy environment, Black parents must also contend with an educational system that has negative perceptions about Black parenting and the ability of Black students to persist in rigorous STEM settings. One of the main reasons for such a critical view of Black parenting is the cultural differences that for Black parents are the norm, but that contrast to the White mainstream perception of effective parenting. Additionally, the power structure of the educational world, which puts teachers and school personnel on a higher level than Black parents, create a dynamic where Black families feel subordinate to the dominant White culture—especially in moments where they are attempting to advocate for their children (McGee & Spencer, 2015). In a society where each previous generation of Black students had more difficult educational circumstances than the following generation, and the fight for educational equality was more intense, Black parents face unique challenges to ensure their children receive an education that is up to par. Due to the sometimes the hostile nature of parent-school relationship, Black parents are forced to teach their children to advocate for themselves to achieve the educational outcomes they feel they deserve.

White-centeredness is present in many aspects of American culture, including math education. As a result, the low performance by Black students in mathematics has not been prioritized as a key issue that needs to be remedied. In fact, Bell’s (2004) work on interest convergence indicates that, until the performance of Black students in math becomes an issue for the majority of the population, there will continue to be a lack of concerted social efforts towards bridging the performance gap. As the White demographic majority decreases, decade after decade, and America becomes more racially diverse, one has to wonder if such infrastructural disregard for the performance of racial minority groups will continue when those groups constitute the majority in achievement data. Data would suggest that America is headed in the direction of a non-White majority sooner rather than later, and though it will likely take longer for the adult percentages of non-Whites to surpass the White percentage, that will most certainly occur more rapidly for school-aged children.

The math achievement data, which is aggregated every two years, shows that since 1990, the percentage of White students who are in math classes has decreased every two years. The percentage of Black students in math classes has decreased slightly over the same period but the bridging of the gap is primarily driven by the fact that the percentage of Hispanic students in math classes has increased every two years (NAEP). For 4th grade students, the percentage of students in math classes that were White decreased from 75% in 1990 to 48% in 2019. For 8th grade students, the percentage of students in math classes that were White decreased from 73% in 1990 to 49% in 2019. For 12th grade students, the percentage of students in math classes that were White decreased from 66% in 2005 (the first year for which 12th grade data is available) to 52% in 2019 (NAEP). A big takeaway from the data is that the younger the grade cohorts are, the lower the percentages of White students in that cohort. Moreover, as Bell (2004) writes, “Even when interest-convergence results in an effective racial remedy, that remedy will be abrogated at the point that policymakers fear the remedial policy is threatening the superior societal status of Whites, particularly those in the middle and upper classes” (p. 69).

Fundamentally, there is a national incentive for Black students to perform better in mathematics as their results contribute to the overall profile of the American students. This is not to say that the math education landscape is intentionally designed to fail Blacks, but one has to wonder what changes would be made, and the immediacy with which they would occur, if the racial demographic representing the majority, rather than Blacks, was at the bottom of the performance rankings. The truth is, the interests have, in reality, already converged. Improving the mathematical outcomes for Black students in math benefits everyone, not just Blacks—it is just a matter of getting policy makers and educational leaders to fully recognize that. There is no real benefit to anyone in having an under-educated society.

Nasir (2016) explores three key reasons why race and culture should be considered in mathematics education:

1. Our society is racially stratified, and students experience access to high quality mathematics instruction by virtue of race.
2. Racial stereotyping influences access to mathematical identities for students, and thus disrupts mathematics learning.
3. High-quality mathematics instruction (potentially) disrupts unequal access to mathematics learning for students from marginalized groups. (p. 10)

To not consider race in mathematics education would presume that all races of students have an equal opportunity to learn math, which they do not. Black students are at a clear disadvantage based on the schools they attend, which is reflected in student results. Black and Latino male students are also subjected to higher rates of school discipline than White students which leads to more time out of class and fewer learning opportunities (Monroe, 2005). Annamma et al. (2013) note that racism often exists and functions in unspoken ways and perhaps no way can be more unspoken than ironically trying to deny the observation of race so as to appear non-racist. A color-evasive classroom approach creates dysfunctional education ecologies where students of color are lost as outflows rather than positioned as valuable resources (Annamma & Morrison, 2018).

Racism and Ableism in Mathematics

According to Annamma et al. (2013) “A DisCrit theory in education is a framework that theorizes about the ways in which race, racism, dis/ability and ableism are built into the interactions, procedures, discourses, and institutions of education, which affect students of color with dis/abilities qualitatively differently than White students with dis/abilities” (p. 7). Moses and Cobb (2001) very clearly lay out the connections between race and a student’s ability to learn - namely, the lack of access for students of color to schools that even offer advanced math and science courses. As a result of the No Child Left Behind legislation, which requires schools and districts to disaggregate performance data, there is increased emphasis on student performance comparison by demographics (Jackson & Wilson, 2012). Analyses of math student assessment data by school leadership emphasizes comparisons based on race, as the underperformance of some racial groups can lead to increased scrutiny of educational practices. The underlying assumptions by many teachers of what students of color are mentally and intellectually capable of, as compared to White or Asian students, indicates a hint of ableism that falls in contrast to the benefit of the doubt and positive expectations extended to their counterparts who are presumed to be more capable of high achievement. Leonardo and Broderick (2011) acknowledge that schooling constitutes some students as “smart” and others as “not-so-smart” in a manner that creates positions of intellectual superiority and entitlement to cultural capital for those deemed smart. They further elaborate on how intelligence is very clearly defined in racial terms, with Blacks falling generally at the bottom of that hierarchy; however, it is rarely acknowledged that the disabled are also typically excluded from the community of the intelligent (Leonardo and Broderick, 2011). The deficit perspectives regarding the supposed limited mathematical abilities of Black students create classrooms where teachers internalize these perceptions and fail to provide truly rich learning opportunities (Jackson, 2009).

The racialized stereotypes involving mathematics achievement extend beyond teachers to students as well. A study of 150 fourth to seventh grade students and their awareness of, and belief in, racial stereotypes and math achievements, indicated that students believed Asians were the smartest at mathematics, followed by Whites, then Latinx students, and finally Black students (Nasir et al., 2017). Even worse is the fact that these beliefs intensified as the students got older, and Latinx and Black students were more likely to be aware of the negative racial stereotypes than Asian and White students (Nasir et al., 2017). It then becomes clear that Black students not only realize that students and teachers alike consider them to be inferior math students, but they also tend to take on those beliefs, themselves. It has been shown by Dalton et al. (2007) that students with high educational expectations are likely to earn more math credits in high school. The lack of confidence in the abilities of Black students in math negatively impacts their performance in the subject as they internalize pervasive sentiments that they do not possess the inherent skills needed to be successful math students. The compound impact of teachers, peers, and Black students, themselves, maintaining mindsets of math inferiority combine to create a social construct wherein it becomes difficult for Black students to demonstrate math competence from a growth rather than deficit mindset. Black students taking math courses, in turn, feel like they have to prove themselves to be competent rather than feel they are given the benefit of the doubt. As a result, they take fewer math classes which sets them up to be minimal contributors civically to a society that has failed them in almost all facets of life. In the same way Smith (2004) recognizes that hierarchy occurs not only through Whiteness but within it, due to educational practices and institutions that marginalize and label students of color, perceptions regarding the abilities of Black and Latinx students are applied not only to them, but also by them. This creates an educational environment where essentially no one has faith in the mathematical abilities of Black and Latinx students, including the students, themselves. Of the seven DisCrit tenets, these concepts connect closely to the following:

> Tenet (4): DisCrit privileges voices of marginalized populations, traditionally not acknowledged within research.
>
> Tenet (5): DisCrit considers legal and historical aspects of dis/ability and race and how both have been used separately and together to deny the rights of some citizens (Annamma et al., 2013, p.11).

Taking an interrogative approach, Subini Ancy Annamma, David Connor, and Beth Ferri, the authors of *Dis/ability critical race studies (DisCrit): theorizing at the intersections of race and dis/ability* ask, “How might DisCrit further expand our knowledge (or understanding) of race and dis/ability?” (2013). In defining a disability, the authors write, “In other words, societal interpretations of and responses to specific differences from the normed body are what signify a dis/ability” (Annamma et al., 2013, p. 3). Of particular note is the use of the term “normed body” in this quote. Of course, the norm is generally determined and associated with the dominant demographic or population in a society, and considering Whites are the majority in America, it is no surprise that there are multiple intersection points between disability and race. The authors further articulate:

> Moreover, the very notion of difference relies on something else being normative. We are all different from one another. In other words, a person who is perceived as having a dis/ability is no more or less different from someone who is considered nondisabled than that nondisabled person is different from him/her. Yet, the person with the dis/ability is perceived as the one who is inherently

> different. However, there can be no difference without a norm, upon which difference is measured (Annamma et al., 2013, p. 10).

In fact, the authors state, “Despite this change in definition, however, African American students continue to be three times as likely to be labeled mentally retarded, two times as likely to be labeled emotionally disturbed, and one and a half times as likely to be labeled learning disabled, compared to their White peers” (Annamma et al., 2013, p. 3). Though these statistics are compelling, more compelling, perhaps, would be the percentage of educators who, if surveyed, would say they are surprised by these numbers. Though appalling, our society has come to expect data of this nature that reflects the inequity in how students of color are labeled, marginalized, and segregated.

Perhaps the maintenance of racism and ableism in separate, non-intersecting silos serves to further prejudiced policies, as a perceived disability provides an out by which administrators can segregate students of color based on a difference that can supposedly be measured somehow. Segregating based on race is illegal (now) and, as such, “Segregation, particularly of black and brown students labeled with a disability, would be illegal if based upon race, but is allowed because disability is seen as a ‘real’ rather than a constructed difference” (Annamma et al., 2013, p. 13). If school leaders and administrators believe there is no association between racism and ableism—and furthermore, how both are socially constructed, they can pass and implement clearly prejudiced policies under the guise of adjusting to the norm. If the narrative is shifted and disability is acknowledged as a constructed difference, many of the practices and policies that exist will fall outside the bounds of legality. Examining this concept more deeply with respect to dyscalculia, it begs the question of whether it is a constructed disability. Numerical learning is measurable, but who determines the benchmarks regarding evaluation and their importance?

Perhaps with any learning disability, the construction of it is not in the evaluation, but in how and why the metrics used to measure it are selected.

Developmental dyscalculia, which has a prevalence of 3% - 6% in society, is a learning impairment that affects arithmetic and numerical functions at a behavioral, psychological, and neuronal levels (Kucian & von Aster, 2015). Dyscalculia persists into adulthood, and as with most disabilities, early detection and treatment are critical (Kucian & von Aster, 2015). Consideration of the aforementioned points begs the question of whether or not the prevalence of dyscalculia is, in fact, higher than reported, as the symptoms are so difficult to recognize and can be masked by comorbidities, or simply the assumption by parents and teachers that struggles with numerical work are so common in America, that they do not cause any alarm. As early treatment and diagnosis are important to treatment, children who are not diagnosed early on carry their numerical impairment with them for the rest of their lives—having no clue they have a disability. Accurate diagnosis of dyscalculia requires multidimensional assessments of numerical, arithmetic, neurological, sensory, and motor processes, among others (Kucian & von Aster, 2015).

In other instances, many students struggling in math are actually low achieving rather than possessing a mathematical learning disability. Low achieving students have no serious cognitive deficits that would prevent them from learning math with appropriate instruction while students with mathematical learning disabilities possess working memory and fact retrieval deficits (Geary, 2004). Garelick (2016) notes that sometimes an assignment to special education services can be more about the conflation between effective instruction in early grades than actual disability. On many occasions, for students from disadvantaged backgrounds who received subpar elementary education, participating in effective instruction through special education services brought them up to speed as they had no specific learning disability. Garelick (2016) notes the increased number of students identified as having learning disabilities in recent decades – begging the question of how many were mistakenly classified due to poor instruction, particularly for mathematics where curricular changes over the years have created an inquiry-based math instructional model that many fundamentalists consider to be abstract and overly confusing. Annamma et al. (2013) recognized that the perspectives of marginalized groups have been ignored in traditional research and education reform and urged academic activists to explicitly talk back master narratives around disability. In fact, not recognizing race is, itself, a privilege only afforded to Whites as it is something they rarely have to consider because when "Whites construct taxonomies of race, they do not perceive that they themselves are raced" (Smith, 2004, p. 2).

It is clear that numeracy and literacy are not mutually exclusive, as many mathematical learnings are found in literature; however, it is the value placed on the fundamental concepts associated with each that is in question. Moses and Cobb (2001) support this theory when they write, "Because the new technologies give rise to computers and an ever-widening use of symbol systems and quantitative data, we concluded that the schools and curricula we had to struggle to design *must* put mathematical and scientific literacy on par with reading and writing literacy" (p.116). Shortcomings in this regard result in secondary school graduates who are ill prepared for world that rapidly evolved, with respect to technology, outside of the classrooms where pedagogical practices remained stagnant and uninformed by modern day concerns and realities. Even considering the learning disabilities associated with numeracy and literacy, dyscalculia and dyslexia, respectively, the latter is easily more recognizable in the American lexicon – pedagogical or otherwise. How many people, educators or not, are familiar with dyscalculia and know its meaning? Furthermore, like all disabilities, dyscalculia is socially constructed which makes it vulnerable to the whims of a society that has demonstrated a lack of awareness or major concern to combat disability.

The significance of an education centered around mathematics and science is of the utmost importance – particularly for communities of color who were traditionally excluded from the civic process via various discriminatory means, including the denial of education and literacy (Fenton, 2016). Bennett (2001), Giroux (1997), and Smith (2004) acknowledge that in societies dominated by White privilege, people of color are denied material equality in addition to cultural and political equality, and the impact of that racism is socio-economic and class-based. In the 1960s, it was the right to vote that ensured full civic participation. In present day society, it is mathematical knowledge and education. The educational debt owed to communities of color greatly exceeds that owed to the American population, at large, as academic access to schools offering the requisite mathematics and science courses needed for civic involvement are largely limited for students of color - who generally attend under resourced schools (Thorius & Pan, 2016). Additionally, students of color have less access to college and career pathways and are more likely to attend schools with fewer qualified teachers (Darling-Hammond, 2010). Tomlinson (2016) notes, justice is not served in a competitive society that allows economic and educational opportunities for one individual at the expense of others, to be determined not by fairness but, rather, privilege and access.

Using cultural historical activity theory (CH/AT), it is evident that the dominant ideologies that existed in the 1960s regarding American students' mathematical abilities still exist today – likely in part because historical contexts inform contemporary thinkers' perceptions of ability. Mendoza et al. (2016) "argue that inequities are mediated and perpetuated by common sense beliefs about ability, race, and racialized communities, which facilitate human interaction and relationships within educational milieus" (pp. 3-4). For the experts in 1967 to not have been surprised about America's poor international ranking in math ability, the dominant ideology of U.S. inferiority must have already permeated society, and the educational sphere, in particular, via cultural mediation and artifacts. Additionally, the notions of inferiority extend even further to minorities and disabled students who are commonly presumed to be low performers. Many educators believe mathematics is a racially and culturally neutral discipline, however, Nasir (2016) notes learning is "an inherently cultural endeavor that occurs in the context of cultural practices, which happen in relation to cultural artifacts and social interactions carried out to achieve socially and culturally defined goals" (p. 8).

For disabled students, especially, despite the ubiquity of disability, it is often overlooked or even erased from the narrative as disability is mediated by other social identities that are more distinguishable (Fenton, 2016). Dis/crit acknowledges that every individual possesses multiple dimensions of identity, either abled or disabled, and that the farther one deviates from the White, male, cis-gender norm, the more deeply the circuit of interlocking marginalizing processes classifies one as disabled (Annamma & Morrison, 2018). An educator can walk into a classroom and subconsciously easily recognize, more often than not, a student's race, gender, and even other cultural indicators. Disability, on the other hand, can be masked by a lack of student participation, unalarming academic performance, or a lack of expertise on how to recognize or diagnose it. Due to the importance placed on literacy in American society, a dyslexic student is likely more commonly recognized by teachers based on their writing or reading habits rather than judged on their performance, whereas a student who suffers from dyscalculia is simply likely to be considered unskilled at math. Moreover, as it relates to mathematics, the results of the first international comparison, the interpretations of the results, and the NDEA, itself, have become artifacts that inform current interpretations of race and ability from both a material and ideational standpoint – with each carrying its own set of histories and norms (Mendoza et al., 2016). These histories and norms manifest themselves in how attitudes about ability and race, specifically as it relates to mathematics, are shaped today.

Conclusion

Those alive when the Sputnik was launched likely remember the secondhand embarrassment felt for the American government by its citizens as they lost a race against a seemingly less able counterpart. The fact that the Federal government had to pass laws to put an emphasis on mathematics in the American educational system will forever live on as an artifact of the means that had to be undertaken to stress the importance of numerical aptitude. The underperformance of American students, as compared to other nations on an international level, has derived to a micro level domestically, including associations regarding which races and ethnicities are gifted at mathematics and which are not. What these artifacts and histories do not do, however, is acknowledge the nuance of an infrastructure that was never designed to lead to success in math, and specifically designed to marginalize Black and brown minorities into spaces where they were less likely to be academically successful.

The reverberations from the impact of the Soviet Union beating the U.S. to space are still felt today, and will likely never be forgotten. During his State of the Union address in 2011, President Barack Obama stated:

> Half a century ago, when the Soviets beat us into space with the launch of a satellite called Sputnik, we had no idea how we would beat them to the moon. The science wasn't even there yet. NASA didn't exist. But after investing in better research and education, we didn't just surpass the Soviets; we unleashed a wave of innovation that created new industries and millions of new jobs.

> This is our generation's Sputnik moment. Two years ago, I said that we needed to reach a level of research and development we haven't seen since the height of the Space Race. (The White House, 2011)

America has shown great resilience in the face of adversity, and an ability to bounce back from setbacks and losses. Though it is still the preeminent global superpower, the U.S. will need to employ all resources at its disposal to account for the disparity between its international standing on a political and economic front, and its international standing as it pertains to educating the youth in mathematics. Though it cannot expect this to maintain in perpetuity, in spite of average achievement in mathematics as compared to other nations, the U.S. has managed to maintain its lead on other nations in the race to international enduring preeminence.

The global race is still on, however, and this is a battle being fought on multiple fronts - with the U.S. ranking poorly on an international scale in both literacy and numeracy. America, with its decentralized education system that allows most decision-making to be decided on a state level, claims to put so much value into education and what our standing means for our role as a global economic superpower, but fails to proffer the appropriate supports to racial minorities and disabled persons. The elite jobs and educational opportunities are reserved for the privileged and abled. Economic prosperity and the U.S. education system are inextricably linked, with the latter clearly demonstrating a need for significant improvements. If, even with lackluster educational outcomes in mathematics and literacy, America remains internationally competitive, and perhaps even dominant, it seems unlikely the Federal government will intervene in any significant way. If the educational system can fail so many marginalized groups so significantly, and the country can still succeed, things must be okay, right? The racial demographics of the

United States are gradually shifting, however. It remains to be seen is how America's poor K-12 performance in mathematics will impact a future, more diverse, and less White, America. It will be interesting to observe how the Federal government reacts when the structural issues that permeate America's societal infrastructure start to adversely impact more than just the minority, as the current minorities become the future majority.

Ultimately the failure of the educational infrastructure to appropriately advance mathematics, at large, and even more so for marginalized groups, becomes a blame game. As Tomlinson (2016) states, "There appears to be little political will to examine causes or solutions other than blaming families, schools, and teachers. Though governments endorse the notion of a 'global skills race', there continues to be minimal interest in and a reduction of funding for vocational education" (p. 165). The general narratives around blame are teachers blaming students for not caring about their education and taking it for granted, the teachers not being trained well enough to teach properly, the bureaucratic nature of school systems makes it impossible for teachers to effectively do their jobs, or families just do not value education in households the way they used to. Regardless of whether or not it is presented as a blame game, there is some truth to all of those narratives and some justification for how the subjects of those narratives came to embody the ideologies. Many primary and secondary school students give off the impression they do not care about their education because they feel the educational system does not care about them. The apathy they demonstrate is a defense mechanism to deflect from the judgments they know they receive from both teachers and peers. Teachers often bend their pedagogical philosophy to the whims of the administration for which they are working, and the adjustments can be misaligned with the ideal approach to effective math instruction. Parents care about the educational outcomes of their children, but they lack the time and, oftentimes, due to evolving educational practices, lack the expertise, to contribute significantly to mathematical mastery beyond primary school.

Despite whom levies blame against whom, it is the students who suffer. The truth is, as stated by Mendoza et al. (2016), effective learning is a shared responsibility, and ultimately not the dissemination of information but, rather, the organization of the learning environment. Considering the school learning environment as co-constructed by students, teachers, and the classroom setting spreads responsibility around evenly and, thereby, contributes to fewer deficit perspectives from teachers as they consider student struggles (Mendoza et al., 2016). As mathematics instruction and curriculum have evolved - with a shift to national common core standards – educators often feel hamstrung by teaching requirements that conflict with their theoretical approach, and parents feel even less comfortable supporting their children's numerical learning. This shift has not only widened the disparity between literal and numerical emphasis but has also exacerbated the inequalities that already exist along racial and socioeconomic lines. As a result, America is now at a point where it attempts to compensate for years of complacency by attempting to prioritize STEM, with disappointing results. To avoid another Sputnik moment, America must counterbalance centuries of intolerant, ablest, and sexist practices, upon which mathematics education was founded, with meaningful, substantial, and equitable policies that shift society to prioritize numeracy equally with literacy.

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