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Eyes Wide Open: E(race)ing Color-Blindness in the Math Classroom

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Introduction and Rationale

With ever-growing political pressures due to violence and xenophobia towards African Americans, Latin@s, and Asian Americans, a renewed interest in anti-racism has emerged in the United States. The social sciences and humanities readily adapt to address social, political, and cultural issues around race. Much of the field of mathematics education, however, has remained steadfast in its allegedly color-blind approach to teaching content standards.

Mathematics has often been described as "beautiful" in the way in which it allows people to explain the world around them. Science, engineering, technology, and data within the social sciences all rely heavily on the use of mathematics. Even the fine and performing arts have foundations within mathematics. Given how math is deeply embedded in our racialized society, the intersection between math education and race cannot and should not be ignored.

The call to use mathematics education to empower others and to create social change is not new. Danny Martin calls into question the purpose of mathematics education. He suggests a reprioritization of mathematics knowledge toward endeavors that promote equity by serving and bettering the community.[1] Eric Gutstein further suggests that mathematics education should serve as a social justice project, "integrating what he has identified as classical, critical, and community knowledge."[2] The National Council of Teachers of Mathematics infused a focus on equity within its standards of practice in the 1980's.[3]

The focus of this curricular unit is twofold. The first is to consider the math classroom as a racialized space. In doing so, the unit will shed light on why math education is not race-neutral and will explain how color-blindness reinforces the oppression of students of color. The unit will examine how color-blindness within mathematics education ignores historical data and blames academic failure on students, their families, and their communities without recognizing the systemic biases that reproduce racial inequality through material stratification, deficiency framing, and reduced access to high quality instruction.

The second part of the unit will consider anti-racist teacher-centered instructional strategies that directly address inequality in math instruction. Among these strategies, the unit will consider teaching for understanding, group participation through complex instruction, culturally relevant pedagogy, and teaching mathematics for social justice. To achieve this, the unit will provide several examples of activities that approach mathematics instruction from a culturally relevant and critical lens. Then, the unit will examine a brief race-neutral Calculus lesson on integral approximation and will highlight components that reinforce systemic racism. Finally, the unit will then address what changes must be made within the sample lesson to better address issues pertaining to race in the math classroom.

Background

I teach at an urban high school where the student population is approximately 60% Latin@, 30% black, and 10% other. The school follows an 80-minute A/B block schedule with four classes each day. Students are required to complete four math courses to graduate including Algebra 1, geometry, Algebra 2, and a math elective. The school has three levels of instruction, Advanced Placement (AP), honors, and college prep. Two AP math classes are offered - AP Calculus AB and AP Statistics. There is one section of AP Calculus AB and two sections of AP Statistics. There is also one section of honors calculus and two sections of honors statistics. Despite the racial composition of the student population, approximately 50% of students taking AP Calculus are white while 25% of students taking honors Calculus are white. Meanwhile, approximately 44% of students taking AP Statistics are white while less than 15% of students taking honors statistics are white.

How students are assigned into 9th grade math courses also carries racial bias. Fifty percent of 8th graders in my district take Algebra 1, yet many are forced to retake Algebra 1 in 9th grade due to underperformance on an end-of-course exam. White students disproportionately start 9th grade in geometry, while students of color start in Algebra 1. This affects which math elective 12th graders can select given the typical sequence of Algebra 1, geometry, Algebra 2. White students can typically reach calculus through the normal sequence, but 9th grade students of color who take Algebra 1 must double-up in geometry and Algebra 2 during 10th grade in order to complete pre-calculus in 11th grade and calculus in 12th grade. Statistics is accessible after completing Algebra 2, making it more accessible to students starting 9th grade in Algebra 1.

It cannot be a coincidence that my school's highest level math classes disproportionately serve white students. Enrollment in AP math classes is only restricted by successful completion of the prerequisite math courses (honors Pre-Calculus for AP Calculus or honors Algebra 2 for AP Statistics). So how are students funneled between honors and AP math? This question is the driving force behind my unit. Once the systemic issues that reinforce racial disparities within my school are acknowledged, the conversation about solving these disparities may begin.

Defining Equity in the Math Classroom

Rochelle Gutierrez defines equity in the math classroom as "the inability to predict mathematics achievement and participation based solely on student characteristics such as race, class, ethnicity, sex, beliefs, and proficiency in the dominant language."[4] Her definition includes four dimensions: (1) access, (2) achievement,

(3) identity, and (4) power. Accessibility refers to the tangible resources students have access to, including quality instruction, rigorous curriculum, reasonable class size, technology, and a classroom environment that promotes participation. The achievement dimension examines tangible results for all students, including test scores and access to higher level classes within course progressions. Identity refers to the ability to see oneself reflected in the curriculum, making mathematics meaningful and significant. Finally, Gutierrez describes the power dimension as a way to measure whose voice is heard in the classroom, who gets to make decisions about what is taught, and how it is used. Power gives students the opportunity to use mathematics to critique society and the world around them.

Together the four dimensions allow us to measure how successfully students can navigate their own mathematics education along two axes. Access and achievement make up the dominant axis that measures how well students "play the game called mathematics."[5] That is, these are the necessary components students will need to show mastery in math as currently defined by the dominant culture. Meanwhile, identity and power comprise the critical axis, which measures students' ability to change the game. The critical axis empowers students by making mathematics relevant and framing students as doers of mathematics, not just receivers of knowledge. A natural tension exists between these two axes, but Gutierrez argues that both are necessary to have true equity in the math classroom.[6] Not all dimensions, however, have to be focused upon equally at all times. At times it will be necessary to focus on the dominant axis and to deprioritize the critical axis. At other times, the opposite will be true. Teachers must find balance and aim to focus on all four dimensions throughout the course.

Critical Race Theory and Accessibility

Critical Race Theory (CRT) was developed in the 1970's in response to a lack of faculty and curriculum diversity at Harvard Law School.[7] CRT attempted to expose the inequity of seemingly neutral laws that disproportionately affected people of color. CRT makes two assertions: (1) race is a social construct, and (2) racism is common and systemic.[8] To better understand these assertions, we must more clearly define whiteness.

Critical Race Theorists argue that race is a social construct rather than a biological descriptor or identity. As such, whiteness is an ideology that functions through institutionalized racism, advantaging those who benefit from their whiteness without overt or malicious intentions.[9] Individuals need not be racially conscious of their whiteness to "reap unearned privileges."[10] In fact, the definition of "white" has changed throughout history. Groups, such as Italian and Irish Americans, Jews, and Russians, who were once persecuted for otherness have since been extended membership. While membership does not erase past oppression, encompassed groups inherit and benefit from new privileges within this passive collective. Expanding the definition of whiteness over time indoctrinates a wider audience, which strengthens the "dominant position that produces white privilege," and further normalizes whiteness and oppresses those outside the white boundary.[11]

Whiteness positions "White people, White ideas, and White behaviors as more valued institutionally and in classrooms, which may not always be visible in terms of curriculum designers and policy developers."[12] This mentality creates a form of covert, color-blind racism that does not outwardly discriminate against people based on appearance, but rather is based on a deficit mindset centered on "student failure, uncaring parents, and devaluing education."[13] This deficit mindset ultimately impacts access to quality mathematics instruction as described by Gutierrez.

Beyond symbolic or ideological notions, racism has a very real material impact on educational access. Seemingly color-blind policies that affect housing, taxes, and education produce “material stratification in resources” that disproportionately affect people of color in a negative manner.[14] For example, tax policy that increases taxes on products is commonly known as regressive taxation, as it has a disproportionate impact on lower income individuals. Likewise, decreasing capital gains taxes disproportionately benefits wealthier individuals. These policies may seem race-neutral on the surface, but in reality they reinforce white privilege.

Funding differentials in schools are closely tied to local taxes and appear between urban and suburban school districts. Based on U.S. Census Bureau data, the median household income in Greenwich, CT from 2015-2019 was $152,577 while that in New Haven, CT was $42,222.[15] According to the Connecticut State Department of Education, the Greenwich School District population was approximately 61.4% white. The district spent $22,370 per student in the 2019-2020 school year.[16] Meanwhile, the New Haven Public School population was 12.4% white with district expenditures being $16,751 per student in the same year, approximately 25% less.[17] School funding greatly impacts teacher quality, instructional materials and curricula, technology within schools, transportation, and achievement test scores. The starting salary of a new teacher with a Master’s degree in Greenwich during the 2020-2021 school year was $61,932[18] while New Haven’s starting teacher salary was just $47,551, approximately 23% less than in Greenwich.[19] With such large differentials, it is not surprising that Greenwich School District math teacher openings are rare while New Haven Public Schools openings are common. Frequent turnover means spending even more resources finding and training new math teachers.

Achievement and the Opportunity Gap

The gap in mathematics achievement between students of color and white students is well documented. During the COVID-19 pandemic, numerous reports indicated a widening of the gap. According to data reported by McKinsey and Company, schools in which over half the student population was white tested 31% lower than the historical average in mathematics on the i-Ready platform while schools comprised primarily of students of color tested 41% lower than the historical average.[20]

Gutierrez criticizes the notion of gap analyses as a form of measuring equity because it decontextualizes the data, thereby ignoring possible solutions. Gap analysis only considers the dominant axis – access and achievement. “Without the larger socio-political frame, achievement gap analyses perpetuate the notion that the problem of low achievement is” something that can be fixed by improving resources.[21] Research abounds within math education on how to improve instruction of marginalized students, such as knowing your students in meaningful ways, scaffolding instruction upon prior learning, maintaining high expectations, believing all students are capable of learning advanced math, focusing on conceptual understanding, and building an environment that promotes cooperation and discourse. Yet despite all this research, the “achievement” gap persists. In fact, what is needed is not just a change in teaching strategies, but also a change in the curriculum to make mathematics meaningful and culturally relevant to students. The critical axis of equity must be addressed. Gutierrez suggests that solution-driven research that examines the context of schools and math programs that have successfully improved equity is essential.[22]

Identity and Deficit Mindsets

Deficit mindsets are endemic to color-blind math classrooms. The notion of an achievement gap reifies a mathematical hierarchy with "Whites and Asian Americans at the top."[23] By not acknowledging students as part of a larger cultural group, teachers miss critical opportunities to use "cultural knowledge about their students that could be used to communicate mathematical concepts and provide the scaffolding necessary for learning."[24] When students struggle to connect with the teacher's perspective, teachers often develop deficit views of their students. When this mindset infiltrates schools, expectations are lowered and students are given fewer opportunities to use math in meaningful ways.

Meritocracy is the philosophy that any student can be successful if they work hard and persist. This idea is often used to justify color-blind philosophies. Laurie Rubel challenges meritocracy by asserting that "teachers who claim color-blindness…are, in effect, refusing to acknowledge the impact of enduring racial stratification on students and their families."[25] In failing to recognize how race impacts the way in which students navigate the structures of education, teachers adopt a deficit mindset that supports the notion that failure stems from "a lack of effort or ability."[26]

Students recognize deficit mindsets in their teachers when teachers more frequently call on the "smart" students who can quickly learn and regurgitate math facts and procedures. Children who cannot answer quickly are often avoided, creating an unspoken message that these students are "dumb" or have nothing to contribute to the overall class. By the time students get to high school, students embody a clear mathematical identity as either being "good" or "bad" at math. This mindset is detrimental in a number of ways. Students who believe they are bad at math are less independent, put forth less effort to learn, more frequently doubt their own ability and work, are less likely to ask peers for help, and more frequently degrade themselves when struggling in the classroom.[27]

The deficit mindset is not unique to students. Despite the best of intentions, even good teachers fall victim to this mindset. Teachers tend to shelter their students from things with which they are not confident students can be successful. Gutierrez examined 23 math teacher candidates as they were introduced to the Interactive Mathematics Program (IMP), which would be used with a class of urban high school students. While the teacher candidates initially lauded the program for its focus on conceptual understanding and application, they later identified the program as being insufficient for their population of students who lacked the necessary prerequisite skills and reading fluency to accomplish such high level tasks. Expectations were immediately lowered when theory needed to be put into practice. Teacher candidates were surprised to later discover that the students had already successfully engaged in IMP.[28] A similar mentality arose among most teachers within my own district when attempting to implement the College Board curriculum Spring Board. The Common Core State Standards of Mathematics identifies skill, conceptual understanding, and application as *equally* important components of rigor in the mathematics classroom.[29] A sure sign of the presence of a deficit mindset is a prioritization of skill over conceptual understanding and application. Without these two pillars of rigor, students will continue to struggle to find significance and relevance in their study of math.

Power and a Call to Action

The National Council for Teachers of Mathematics (NCTM) published the book *Catalyzing Change in High School Mathematics* (CCHSM) in 2018 as a call to create change within traditional approaches to math education. While never overtly calling the math classroom a racialized space, the authors clearly identify a lack of equity within math education as a primary concern within high schools. NCTM identifies four primary challenges for high school mathematics, each centered around the concept of equity.[30]

1. Creating equitable structures within high school mathematics
2. Supporting equitable instructional practices
3. Outlining "Essential Concepts for Focus"
4. Developing equitable and common pathways.

NCTM acknowledges the question that plagues every high school math classroom, "When will I ever need this?" Unlike k-8 mathematics, which is centered on math that students easily see within daily life (money, counting, building, drawing, etc.), high school mathematics is much more abstract and students have more difficulty connecting with the material. This lack of connection makes it more difficult for most to understand the purpose of learning high school mathematics. NCTM therefore pushes teachers to move beyond the college and career readiness response and establish high school mathematics as an opportunity to expand professional opportunities and to create a clear pathway to understand and critique the world around them.[31] This call challenges high school mathematics teachers to step back from traditional approaches that focus solely on the abstract and make room for analyzing what's going on in the world. By this very assertion, NCTM endorses the use of mathematics as a lens through which students can understand and interpret the racial, gender, and income inequalities they experience or see in the news.

Mathematics education has played an important role in developing "national economic and defense interests" since World War II.[32] Careers involving science, technology, engineering, and mathematics (STEM) are growing at a faster rate than almost all other fields and there is currently a severe shortage of graduates in these fields. According to the Bureau of Labor Statistics, between 2009 and 2015, STEM-related jobs grew 10.5 percent compared to non-STEM jobs, which grew at half the pace at 5.2 percent.[33] Simple economic theory of supply and demand reveals that the salaries for STEM careers are rising faster than in almost any other field.[34] In fact, ninety-three out of one hundred STEM occupations had average wages greater than the national average.[35] Thus, increasing access for students of color to these fields is one of the surest ways to close gender and raced-based wage gaps.

The push to use mathematics as a way to critique the world around you, however, extends beyond the call to prepare students for STEM careers. While students should be able to use high school mathematics to explain scientific phenomena, technological advancements, and other STEM related connections, students should also be encouraged to use mathematics to critique social and political systems. This encouragement allows students to develop skills to better navigate statements made in the news, by politicians, or by public interest groups. Mathematics empowers students to understand "their role as members of our democratic society, … to actively engage in their communities, and ... to appreciate their potential power to challenge injustices and contribute to societal improvement."[36]

Addressing Structures that Perpetuate Racism

Addressing the systemic nature of racism can seem daunting for individual educators, but there are four structural barriers that educators and schools can directly influence, namely (1) student tracking, (2) teacher tracking, (3) instructional support, and (4) grading.

Student Tracking

Tracking within mathematics is often seen as a race-neutral default option at most high schools. Tracking separates students into distinct subgroups based on perceived notions of a student's ability. Tracking significantly restricts a student's mobility within traditional high school course progressions and disproportionately regulates black and brown students to the lowest tracks where deficit mindsets are reinforced. Once in a low track, students often struggle to switch tracks due to opportunity gaps that result from content and standard differentials between tracks. Students in the highest track typically receive a three-tier math education, with a focus on procedural fluency, conceptual understanding, and application. In lower tracks, however, the foci on the latter two tiers are typically abandoned. Students in the lowest tracks are typically seen as lacking skills and understanding, without which authentic application is unachievable. Consequently, teachers focus on rote procedures and skip content deemed "too hard."

Detracking is evidenced to lead to greater success for more students.[37] Detracking a high school math program requires a re-envisioning of instruction, math courses, and the traditional progression. Schools cannot simply detrack and expect equity issues to disappear. High schools that successfully detrack use myriad teaching strategies to promote success, such as complex instruction (CI), as designed by Elizabeth Cohen and Rachel Lotan. Complex instruction emphasizes the importance of task design. Teachers generate inherently uncertain open-ended tasks that "force students to draw upon each other's expertise and repertoire of problem-solving strategies."[38] Doing so helps students learn to approach problems from multiple perspectives, justify their reasoning, and communicate effectively.

While teachers may not be able to change the tracking structure within their school overnight, teachers may still have opportunities to affect meaningful change. By identifying and focusing on essential concepts within individual courses and from one course to the next in the tracked progression, educators can ensure that students subjugated to lower tracks develop the necessary understandings required to be successful in future classes and at various levels within the tracked system. Teachers can change the type of tasks they give students by raising expectations and providing multiple points of entry for students. Through continued effort, students can more fluidly switch between tracks until eventually tracking becomes unnecessary.

Teacher Tracking

Teacher tracking is yet another supposedly race-neutral practice in which experienced teachers are often assigned upper-level courses like algebra 2, pre-calculus, and calculus while newer teachers are assigned lower-level courses like algebra 1 and geometry. Teacher tracking has an impact on both students and teachers. When analyzed in conjunction with student tracking, one study found that "marginalized students had access to less effective instruction than non-marginalized students, and that lack of access to high-quality instruction persisted over time."[39] Additionally, teacher tracking tends to result in greater new-teacher burnout, which when left unaddressed, results in increased rates of turnover. According to the Learning Policy

Institute, between recruitment, hiring, and training, urban districts spend more than $20,000 on each new hire, an investment that does not pay off when teachers burnout quickly.[40]

A simple solution to teacher tracking is to balance teaching loads more equally among new and experienced teachers, allowing all teachers to teach both lower and higher levels math courses. Doing so provides a number of benefits. First, it allows new and experienced teachers to more easily collaborate and to learn from one another. Second, it provides teachers with a broader understanding of the vertical alignment of classes. Third, it allows teachers to see the growth of students over multiple years, fostering a strength-based mindset of students.[41] Finally, balanced teacher course loads foster a “collective sense of responsibility for all students.”[42] Detracking teachers requires schools to invest in structured time for teachers to meet, to collaborate, and to discuss instructional practices.

Instructional Supports

The manner in which schools organize and utilize instructional support for mathematics impacts equity. Some schools provide students with a math support class while others increase instructional time within a given course. Not all supports, however, lead to equally equitable outcomes. Schools that utilize two-year algebra courses cause students to fall further behind their peers while two-period algebra classes allot students just as much learning time without the negative effects. Regardless of which route a school chooses, targeted supports should focus on grade-level content and conceptual understanding instead of below-grade procedural skills. Support should occur within the context of the current grade-level content.

Grading for Equity

Grading is perhaps the “race-neutral” practice for which teachers are most protective. Most teachers grade on a 0-100 point scale and grade everything from participation, homework, classwork, quizzes, and tests. These traditional grading practices, however, perpetuate whiteness in a variety of ways depending on how these grades are utilized. If grading is meant to serve as a numeric representation of student content mastery, then homework, classwork, group work, participation, citizenship, and the like should not be graded. Intermediate assignments like homework and classwork provide opportunities for students to practice in an effort to master concepts and skills. Giving students failing grades for unsuccessfully solving problems punishes students for not having already mastered these new concepts. This practice advantages students who participate in enrichment programs or whose families can hire tutors while disadvantaging students who have less free time or opportunities because they need to take care of siblings or work. Meanwhile, grading participation or citizenship reinforces a white ideology of appropriate behavior and bears no reflection on content mastery. Grading for anything beyond mastery inflates compliant students’ grades while deflating defiant students’ grades, which further feeds into inequitable student tracking practices.

Test grades become increasingly important indicators if other assignments are not graded. As in real life (driving tests, SATs, certification exams, etc.), students should be afforded multiple opportunities to prove mastery without consequence. Testing everyone simultaneously conveniences only the teacher and reinforces a fixed mindset about math ability among students and teachers. Students who are good at math should have no trouble passing the test. Test results identify who is smart at math and who is not, and then everyone moves on to the next topic. Equitable grading practices, however, ask students to examine and learn from their errors. Students should then be given the opportunity to re-test. Only the final score should be included in a student’s grade. Test retakes should not be averaged as this practice punishes students for not adhering to the teacher's preconception of how long it should take to master a set of concepts and creates a diminished representation of what the student has actually learned.

Within this same vein, the traditional 0-100 grading structure provides a deflated outlook on what students have mastered by greatly skewing data in favor of what students have not mastered, further reinforcing the deficit mindset that plagues math education. Of the 101 point scale, 60 of the points define what a student has not mastered while 41 points spread over 4 different letter grades differentiate what a student has mastered. This breakdown is unrealistic in the real world. Even Advanced Placement exams don't expect students to demonstrate mastery by scoring a 90% on the test. In fact, a 3 on an AP Calculus exam will earn some students college credit at most public universities. To earn a 3 on the exam, students only need to demonstrate about 40% mastery of all the concepts. A 5 (the highest score a student can earn) only requires students to demonstrate about 65% mastery and guarantees most students credit at a public university.

One possible alternative to the traditional grading scale is not a far stretch from what most high schools already do to provide students with a Grade Point Average (GPA). Joe Feldman recommends the use of a 0-4 scale with no intermediate grades (i.e. no decimals).[43] This strategy assigns each letter grade a number, identical to that of a GPA. The point is not to have teachers just convert percentages to a 4 point scale, but rather for teachers to treat the scale more like a rubric. One sample grading policy had teachers identify what high school students should be able to do with the content. That was assigned a 3. To earn a 4, students had to go beyond that standard. A 2 meant the student was close to understanding, but not quite there. A 1 meant the student showed very little understanding. A 0 represented no clear understanding of concepts. This strategy requires teachers to reflect more deeply on the grading process of what it truly means to master a concept. It also requires teachers to consider the types of questions they are asking students since the focus is on understanding. Using this 0-4 scale accomplishes two things. First, it neutralizes the devastating impact of the zero. Second, Feldman asserts that the 0-4 scale more accurately depicts student mastery.[44] Some critics argue that changing the traditional scale inflates grades and makes it easier for students to earn an A. But Feldman's study showed that while the F and D rates declined, so did the A rate. A focus on mastery instead of compliance will always have this effect. Moreover, Feldman's study found that course grades using the 0-4 scale more closely reflected standardized test scores, "indicating that the teacher's assessment that a student mastered a standard was aligned with that same demonstration on the tests."[45]

Implementing Equitable Instruction

Good teaching is anti-racist teaching. Of course what counts as good teaching is subjective and what many math educators consider good has roots in whiteness. Color-blind math instruction ignores, but doesn't eliminate, negative stereotypes that marginalized students face every day and results in deficit mindsets that place blame of failure on students, their families, and the community. Anti-racist math pedagogy asks teachers to turn inward and examine the structures of the math classroom that sustain racial inequalities and limit student success, such as a unilateral focus on speed and accuracy based on rote memorization. This is not to suggest that speed and accuracy are not important, but rather that its sole prioritization is insufficient in anti-racist curricula. Therefore this section will highlight strategies that attend to the critical axis of equity; that is, identity and power.

Pamela Seda and Kyndall Brown, the authors of *Choosing to See: A Framework for Equity in the Math Classroom*, use the ICUCARE ("I-see-you-care") strategy checklist to suggest seven anti-racist instructional strategies that attend to the critical axis of equity.[46]

1. Include others as experts
2. be Critically conscious
3. Understand your students
4. use Culturally relevant curricula
5. Assess, activate, and build on prior knowledge
6. Release control
7. Expect more

These seven strategies provide a starting place for teachers to address both the identity and power dimensions on the critical axis of equity. Rubel asserts that "instructional practices that encourage opportunities for equitable participation can themselves be an avenue toward social justice, and therefore, a way to teach for social justice."[47] When teachers prioritize conceptual understanding and create space for all students to actively and meaningfully engage in lessons, students develop a stronger mathematical identity as doers of mathematics. Further, examining mathematics concepts through the lens of social justice empowers students to examine and critique injustice in their own worlds. It provides an answer to the dreaded "When will I ever use this?" question. The goal is not to overshadow the standards, but to provide context for the standards, thereby striking balance between the dominant and critical axes of equity. Consider the culturally relevant math activities described below.

Culturally Relevant Classroom Activities

Data Portraits by W.E.B. Du Bois

W.E.B. Du Bois was the first African American to earn a Ph.D. from Harvard University in 1895. Afterwards he became a professor at Atlanta University, where he established what is now known as the first school of American sociology. While at Atlanta University, he taught history, sociology, and economics. Du Bois recognized the power sociology could play in bringing light to social structures that "separated black and white populations, whether that came to educational attainment, voting rights or land ownership."[48]

In 1899, Thomas Calloway, an educator, journalist, lawyer, and former classmate of Du Bois, petitioned the US government to include an exhibit on the progress of African Americans since slavery at the Paris World Fair of 1900. Calloway approached Du Bois about contributing to the exhibit. Du Bois initially planned to include 500 photographs that depicted daily life, but realized the photographs "did not relay the underlining ways that the institution of slavery continued to impact African-American progress in the country."[49] Instead, Du Bois, with the help of a team of colleagues, Atlanta University alumni, and students, set out to create sixty data visualizations to provide a counternarrative.

Du Bois' first set of portraits provided focused data on African Americans in Georgia, which at the time had the largest black population in the United States, while his second set revealed more holistic data of the U.S. black population. Data sets included family budgets, occupations, land and property ownership, literacy rates, and population size, to name a few. Du Bois wielded his portraits as a sociological tool to display the realities and sustained inequalities in America post emancipation. Today his data portraits are not only lauded for the counternarrative they provided, but also for their creativity. Even “before the rise of Europe’s avant-garde movements,” Du Bois utilized a variety of modernist techniques like bright colors and unique shapes and structures to add a layer of complexity and beauty to his data.[50]

Today, journalists, artists, and activists are finding new and creative ways to shed light on inequality in America through data visualizations. Two such projects include the 1619 Project and the Mapping L.A. Project. The 1619 Project was conceived by Nikole Hannah-Jones with New York Times Magazine and “aims to reframe the country’s history by placing the consequences of slavery and the contributions of black Americans at the very center of our national narrative.”[51] The Los Angeles Times’ “Mapping L.A.” project uses an interactive digital map of L.A.’s 114 neighborhoods to engage with and highlight people’s varied experiences and realities throughout the city. Alternative visualizations make data more accessible and thought provoking to the lay consumer. While I do not plan to go in depth into either of these projects, I feel obligated to mention them as further examples of the power behind data visualizations and how they can be used to shed light on inequality within a community. Perhaps they will provide further inspiration for your own work.

The activities that follow provide a jumping off point for math teachers to incorporate culturally relevant activities in their classrooms. I have chosen to provide several examples from a sampling of classes instead of from a single unit in a single class in order to better illustrate how culturally relevant curricula can be used throughout the traditional high school pathways. Each activity was inspired by W.E.B Du Bois’ Data Portraits, which will provide a common theme for the activities. The activities aim to provide a social context in which to recognize academic and social inequality within the community. These activities will illustrate how mathematics can be used to engage students in topics that matter in their communities and open a dialogue about how to create change. The activities do not provide direct solutions to any of the given problems but instead provide an opportunity for students to brainstorm their own solutions. Each task provides a low-floor and high-ceiling, which allows easy entry for all students while raising expectations.

Initial Task: Exploring W.E.B. Du Bois’ Data Portraits

Have students examine selected images from W.E.B. Du Bois’ Data Portraits collection. This will occur as an initial exposure for students to data visualizations. Ask students to reflect on what type of data is on display and what is unique about the way in which Du Bois depicts the data. Ask students to consider why Du Bois thought this data was important to present to the world in 1900.

After giving students some time to just examine the collection, have students work in groups to use the given data on the portraits along with measurements they will take to determine missing data values portrayed in the images. Then, ask students to examine how Du Bois’ art illustrates a counter-narrative to the dominant historical perspective of African Americans in Georgia. You may consider collaborating with an American History teacher to provide a richer context for your students.

For instance, consider the visualization “Negro business men in the United States.” The portrait depicts various sizes of rectangles, but provides no hard numbers. Ask students to measure the dimensions of each rectangle and calculate the areas. By using proportions, students can determine the percentage of African Americans that held each type of job (general merchandise stores, grocers, bankers, undertakers, building contractors, druggists, publishers, and building and loan associates). This assignment can lead to conversations about black-owned businesses within the community.

Also consider the data visualization “Acres of Land Owned by Negroes in Georgia.” The bar graph only provides numeric values for the years 1874 and 1899. Ask students to take measurements and use proportions to determine numeric values for other years. Afterward, discuss trends in the data. Ask students to describe what they see and any growth patterns that might exist. Ask students to consider what the implications of land ownership were for African Americans in Georgia at the time.

Through several activities described below, students will be asked to research similar data in New Haven and Connecticut to create their own data portraits of our city and state. Students will utilize the data portal CT Data Haven, which provides a wealth of statistics and resources on data visualizations for the state of Connecticut. Students will use proportional reasoning and their understanding of area to design their own portraits. Students will be encouraged to display their data in a non-mathematically traditional format reminiscent of, though not necessarily identical to, Du Bois’ own portraits. Students’ data portraits can be displayed throughout the school.

Possible Data Sets Students Can Explore:

1. Racial decomposition of the city by neighborhood (Fair Haven, East Rock, the Cove, the Hill, Westville, etc.)
2. Graduation rates over time by school
3. Racial decomposition of schools and per-pupil expenditures at each school

Algebra 1: School Funding vs. SAT Scores

Students will be directed to EdSight (the CT State Education Data Portal) to research data about various school districts in Connecticut, including Greenwich Public Schools, Westport Public Schools, Milford Public Schools, Naugatuck Public Schools, Middletown Public Schools, New Haven Public Schools, Hartford Public Schools, and Bridgeport Public Schools. Students will examine racial demographics, dollars spent per pupil, average SAT scores, graduation rates, and the percentage of students who qualify for free or reduced lunch. Students will also research median family income and the average home values in each city/town (using Zillow). Students will work in groups to examine the strength and direction of various correlations, such as income and SAT scores or racial demographics and dollars spent per pupil.

Students will then create scatterplots to model the data and will use linear regressions to interpolate and extrapolate data about each of the school districts. Students should consider how school funding and average income impact SAT scores and graduation rates.

Geometry 1: Overcrowding in School

Prior to the pandemic, students often complained about over-crowded hallways at the school. Moreover, there were frequent population comparisons drawn between Wilbur Cross High School and Hillhouse High School (the only two comprehensive neighborhood high schools in the district). Despite having nearly identical blueprints, the two schools do not have similar population sizes. Using outlines of the schools’ blueprints, groups of students will use geometry to determine the school’s square footage, which will then be used to determine the student-per-square foot ratio of various wings and floors of the school. Students will shade blank versions of the blueprints according to the average student density throughout the day. Similar maps will be created of each of the other New Haven High Schools by working with colleagues during district-wide professional development. Students will compare maps and the results with the same ratio for each of the other high schools in New Haven.

Students will use EdSight to collect various statistics on each of the New Haven High Schools, including population size, racial demographics, percentage of students who qualify for free or reduced lunch, attendance rates, graduation rates, and SAT data. Students will examine the distribution of building size, population density, and school funding within the district and will write letters to the Board of Education to make recommendations for adjusting population sizes within the 8 New Haven high schools.

Geometry 2: Hunger and Food Insecurity

Students will explore food access throughout the various New Haven neighborhoods using concepts they learned while studying circles. Students will create three color-coded "maps" of the city depicted as a set of circles. Each neighborhood within the city will be represented by a different color circle. Circles on the first map will be sized based on land area while circles on the second map will be sized based on distance to a large-scale grocery store like Stop and Shop or Price Rite. Circles on the third map will reflect average income within each neighborhood. Students will examine the racial composition of each neighborhood and discuss how the data visualizations they created depict unequal access to healthy food options. Ask students to consider the impact of food accessibility on various neighborhoods in the city. What can be done to address this issue? How might the data visualizations be used to educate others?

Geometry 3: Driving While Black or Brown

Students will be given a bag of various colored marbles that is consistent with the general racial breakdown of the city (they will not be told this information ahead of time). Students will run a brief experiment to see what the likelihood is of pulling a specific color marble from the bag. Students will examine data pertaining to traffic violations in New Haven or East Haven and will then be told that each color marble represents a different racial demographic of the cities. Students will be asked to analyze the results from their experiment and compare them with the actual data for New Haven or East Haven. Students will engage in a conversation about the implications of the data looking distinctly different from a random sampling. Students will once again design a data portrait to represent this data.

*This activity is modeled off Eric Gutstein's "Driving While Black or Brown" project that examined racial profiling of people of color by law enforcement in California.[52]

Examining and Re-Imagining the "Race-Neutral" Math Lesson

This final section of the unit will examine a traditional color-blind calculus lesson. The lesson is comprised of a skills-based warm-up and a period of "me-we-thee" where students receive direct instruction, go through a few skill-based examples with the teacher, and then practice either on their own or in small groups. The lesson focuses on procedural fluency and the teacher is the primary source of information. There is almost no focus on conceptual understanding and learning is somewhat superficial even if students can complete problems quickly.

A Traditional Color-Blind Calculus Lesson

Lesson Objectives

1. Use a Riemann sum to approximate the integral of a function over a specified interval.
2. Explain whether a given Riemann sum will provide an over- or underapproximation of the integral.

Lesson Outline

1. Warm-Up: Calculate Area, x3 problems
    1. Rectangle
    2. Semi-Circle
    3. Trapezoid
2. Direct Instruction to Provide Notes and Examples
    1. Left Riemann Sum, x2 problems
    2. Right Riemann Sum, x2 problems
    3. Midpoint Riemann Sum, x2 problems
    4. How to tell if the Riemann sum provides an over- or underapproximation, x2 problems
3. Independent Practice, x10 problems
4. Homework, x10 problems

Examining the Lessons through a Critical Lens

The traditional lesson emphasizes the teacher as the gatekeeper of knowledge. It fails to recognize that all students bring some level of prior knowledge and understanding that can be drawn upon to establish a positive math identity. The lesson utilizes a factory model approach of “see and replicate” by using a couple examples and repeating the exact process through a large number of skill-based practice problems. The practice problems are out of context and unmeaningful to students, which makes it more difficult for students to engage in the work. Students are informally assessed based solely on how many questions they can answer correctly in the given amount of class time. In the end, students have successfully met the learning objectives and will be able to replicate the given process. However, learning is likely superficial as students are unlikely to be able to apply what they have learned in a different context or explain its significance. Expectations in this lesson are low.

The Lesson Reimagined from an Anti-Racist Lens

Consider the following inquiry-based exploration that draws on students’ prior knowledge to guide their own discovery of key concepts related to Riemann sums. The reimagined anti-racist lesson takes a different approach. This lesson releases control from the teacher and engages students in peer-to-peer discourse as students tinker with an applet to draw conclusions based on their own observations. The teacher merely serves as a facilitator. The lesson fosters a growth mindset by setting a low-floor and high ceiling. The exploratory approach gives students agency. The data portrait at the start of the lesson provides context for how integration can be used to discuss social injustice. This lesson attends to both the dominant and critical axes of equity.

Warm-Up

1. Ask students to sit and work in small groups.
2. Show students the infographic “Proportion of Freemen and Slaves Among American Negroes.”

3. Ask groups to examine the data portrait and write down five factual statements and two questions they have about the infographic.
4. Ask students to find the most accurate estimate of the green area using any method they can think of. Students should show their work and be prepared to discuss how they found their answer.
5. Do a gallery walk so students can examine how other groups approached the problem.
6. Have a discussion to see what strategies students found most effective and why.

Prompting Questions to Guide Student Thinking during Work Time

1. How do you find the area of various shapes?
2. Can the larger area be decomposed into smaller, easier areas to find?
3. What is being measured on each axis?
4. What does the slope of the function represent?
5. What does the green area represent?

Prompting Questions to Guide Post-Gallery Walk Whole Class Discussion

1. Having examined the work of your classmates, what strategies were most effective?
2. What shapes did students use? Why did they choose the shapes they did?
3. If students could only use one shape to make up subunits of the area, what shape would they choose and why?
4. What does the area represent within the context of the data portrait? What information does the data portrait reveal?

Debrief and Transition

After guiding a post-gallery walk discussion, explain that one strategy to estimate the area between a curve and the x-axis is to use a Riemann sum. Introduce the next activity and explain that students will learn more about Riemann sums by working on an investigation together in their groups (3-4 students). The class will discuss the groups' findings at the end of the lesson.

Main Activity: Exploration

This activity utilizes "Calculus Applets using GeoGebra," designed by Marc Renault and supported by Shippensburg University. The applet can be found with a simple Google search. Students will work in groups of 3-4 to complete this activity.

Getting Started

1. Select the applet titled "The Riemann Sum."

1. In the space that says "f(x) = ___", type "1/4(x-3)(x-7)".
2. Select "Relative" and make sure it's set to "right endpoint".
3. To change the number of subintervals used in the Riemann Sum, move the slider under the heading "Number of Subintervals".
4. To change the integral bounds, drag the blue circles on the graph to the lower and upper bounds of the integral expression.

Part A: Change the number of subintervals, lower bound, and upper bound to answer each of the following questions.

1. Find $\int_0^3 f(x)dx$ using 6 subintervals. Record the integral value.
2. Find $\int_3^7 f(x)dx$ using 8 subintervals. Record the integral value.
3. Find $\int_0^7 f(x)dx$ using 14 subintervals. Record the integral value.
4. Find $\int_7^0 f(x)dx$ using 14 subintervals. Record the integral value. (swap the two blue circles)
5. Conclusions:

1. Compare your results to questions 1-3. How are they related?
2. What can you conclude about area that lies below the x-axis?
3. What is the relationship between and $\int_a^b f(x)dx$ and $\int_b^a f(x)dx$?

Part B: Type the given functions into the applet where it says f(x). For each function, state the integral value, then APPROXIMATE $\int_0^7 f(x)dx$ using 7 subintervals with a left Riemann sum and then a right Riemann sum. Finally, indicate whether the given Riemann sum provides an over- or underestimate of the integral value. Record your responses in a table. The Riemann approximation is given by the “Relative” value.

1. Functions
    1. f(x) = $\sqrt{x}$
    2. f(x) = $\frac{1}{3}x$
    3. f(x) = $\frac{1}{8}x^2 - 2$
    4. f(x) = $-\sqrt{x} + 4$
    5. f(x) = $-\frac{1}{2}x + 2$
    6. f(x) = $-\frac{1}{10}x^2 + 4$
2. Compare and contrast the 6 equations. Which equations provided an over-approximation? Which provided an under-approximation?
3. Conclusions
    1. What can you conclude about when a left Riemann Sum will provide an over-approximate and when it will provide an under-approximate? What can you conclude about when a right Riemann Sum will provide an over-approximate and when it will provide an under-approximate?
    2. Complete step 1 again, but this time perform a midpoint-Riemann Sum. Compare the midpoint values with the left-Riemann, right-Riemann, and integral values. Which of the three approximations provides the most accurate estimate of the value of an integral?

Part C: Type the given function into the applet where it says f(x) = . Find $\int_1^7 f(x)dx$ using the indicated number of subintervals and a left Riemann sum. Record your responses in the table below.

1. Let f(x) = $\frac{1}{4}(x-3)(x-6)+1$
2. What is the integral value of $\int_1^7 f(x)dx$?
3. Create a table to record the integral approximation using a left Riemann sum (the “Relative” value) given the following set of subintervals: .
4. Conclusion: Compare your answers with the actual value of the integral. What can you conclude about

the accuracy of the Riemann approximation when you increase the number of subintervals? Why does this occur?

Class Discussion of Conclusions and Final Thoughts

Summarize the conclusions as a whole class to ensure that all students correctly identified the rules and characteristics of left, right, and midpoint Riemann sums. Then, ask students to reconsider the data portrait from the warm-up. What other data might students be able to represent with area? What might those areas represent? For homework, ask students to go to CT Data Haven to find a line graph data visualization that depicts a piece of relevant information to them. Consider what the slope of the line represents and what the area between the function and the x-axis represents. These will be discussed at the start of the next class. Ideas might include voter registration, COVID-19 infection rates, immigration rates, rates of incarceration, or college tuition rates. Students should be prepared to share their chosen data visualization at the beginning of next class.

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Appendix on Implementing District Standards

This unit is designed to provide an overview of strategies to transform color-blind math lessons into anti-racist math lessons. As such, the unit as a whole does not focus on specific math standards as a typical curricular unit would. Instead, a variety of Common Core State Standards of Mathematics (CCSS-M) are met that span a range of units based on the New Haven Public School curriculum. The sample lesson plan and four culturally relevant activities build upon the 8 standards for mathematical practice (SMP) as outlined in the CCSS-M. The remaining standards focus on modeling with geometry.

CCSS.Math.Practice.MP1

Make sense of problems and persevere in solving them.

CCSS.Math.Practice.MP2

Reason abstractly and quantitatively.

CCSS.Math.Practice.MP3

Construct viable arguments and critique the reasoning of others.

CCSS.Math.Practice.MP4

Model with mathematics.

CCSS.Math.Practice.MP5

Use appropriate tools strategically.

CCSS.Math.Practice.MP6

Attend to precision.

CCSS.Math.Practice.MP7

Look for and make use of structure.

CCSS.Math.Practice.MP8

Look for and express regularity in repeated reasoning.

CCSS.Math.Content.HSG.MG.A.1

Use geometric shapes, their measures, and their properties to describe objects.

CCSS.Math.Content.HSG.MG.A.3

Apply geometric methods to solve design problems.

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