The Role of Mathematics in Today's Movement for Racial Justice

Evelyn Lamb, Omayra Ortega, and Robin Wilson

Introduction

"Racism may wear a new dress, buy a new pair of boots, but neither it nor its succubus twin fascism is new or can make anything new. It can only reproduce the environment that supports its own health: fear, denial, and an atmosphere in which its victims have lost the will to fight."

—Toni Morrison

"But all our phrasing—race relations, racial justice, racial profiling, white privilege, even white supremacy—serves to obscure the fact that racism is a visceral experience, that it dislodges brains, blocks airways, rips muscle, extracts organs, cracks bones, breaks teeth. You must never look away from this. You must always remember that the sociology, the history, the economics, the graphs, the charts, the regressions, all land with great violence on the body."

—Ta-Nehisi Coates

"Never forget that justice is what love looks like in public."

—Cornel West

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Using mathematics as a tool to critically analyze systemic racism has a long history in the United States. In 1900 W. E. B. Du Bois predicted, quite prophetically, that "the problem of the 20th century is the problem of the color line." Du Bois was also among the first to invoke mathematics and statistics to analyze issues of racial injustice through his *Data Portraits Visualizing Black America*. The first Black person known to have earned a graduate degree in mathematics in the U.S. was Kelly Miller, who went on to use what he had learned as a graduate student at Johns Hopkins to challenge the flawed statistics of eugenics in Fredrick Hoffman's 1896 book *Race Traits and Tendencies of the American Negro* and, as a faculty member at Howard University, taught mathematics as a tool for understanding social issues. The first known Black woman to enter graduate school in mathematics was Anna Julia Cooper, who later dedicated her life to the struggle for racial justice. Almost a century later, former mathematics teacher and civil rights leader Bob Moses declared that "mathematics literacy is the literacy of the 21st century," and that the failure to provide equitable mathematics education for all has helped maintain the color line that still threatens our democracy.

The 2021 MSRI Workshop on Mathematics and Racial Justice, which took place online in June 2021, was born out of an effort from members of the mathematics community to engage with the national conversation about racial justice that came to the forefront in the summer of 2020 after the video recording of the brutal murder of George Floyd by a Minnesota police officer captured the world's attention. The protests and demonstrations in the months that followed brought the issues of police violence, racial injustice, and anti-Blackness into classrooms, boardrooms,

and dinner tables around the country and around the world.

In response, many institutions began to ask whether there was more that they could do. MSRI has a history of support for diversity and inclusion in the mathematical sciences dating back to the work of former MSRI Director William Thurston and Deputy Director Lenore Blum that led to MSRI hosting the first Conference for African-American Researchers in the Mathematical Sciences (CAARMS) in 1995. So, it was not a surprise when MSRI Deputy Director Hélène Barcelo reached out to members of the organizing committee with an offer to provide a platform for a conversation about race and the math community. They were not initially certain how they should act; they were certain, however, in their conviction that mathematicians can bring unique skills and abilities to the struggle for racial justice that are urgently needed in the world. They decided, with the support and assistance of the MSRI leadership, on organizing a mathematics research workshop that would provide an opportunity for the broader mathematical sciences community to learn about how scholars use mathematics as a tool for understanding and exploring issues of racial injustice.

Our country's history of racism endures despite gains made during the Civil Rights Era and this legacy continues into our present. Educational, financial, medical, judicial, and political institutions are not without culpability in committing injustices towards Black people. Through the workshop, the organizers intended to engage mathematicians and other scholars within the mathematical sciences who might work to dismantle this legacy.

The murders of unarmed Black people at the hands of the state are disturbing echos of the history of the extreme violence of state-sanctioned Jim Crow laws and the lynching of Black people in the U.S. In fact, while we were drafting this introduction, 10 people were murdered in an anti-Black terrorist attack in a grocery store in a predominantly Black section of Buffalo, NY, and the algorithms that govern social media are suspected to have played a role in inciting this violent act.

As mathematicians who see every day the potential for analyzing and guiding solutions to some of the world's most pressing problems, we recognized that it was time for the mathematics community to rally around scholars using mathematics to analyze, study, and guide solutions for the problems of racial justice and to educate and inspire mathematics educators and researchers to take an active role in creating and implementing those solutions.

The MSRI Workshop on Mathematics and Racial Justice focused on the following guiding question: How can mathematics be used to identify and dismantle the ways in which biases manifest in social constructs, specifically those constructs concerning racial justice? The organizers of the workshop selected four key areas on which to focus: Bias in Algorithms and Technology; Fair Division, Allocation, and Representation; Public Health Disparities; and Racial Inequities in Mathematics Education. In this article, we share examples of the thought-provoking talks from the workshop. For a more extensive summary of the workshop events, read the workshop compendium available for download at `http://library.msri.org/msri/Math-and-Racial-Justice.pdf`.

Bias in Algorithms and Technology

In her plenary talk about the sources and consequences of algorithmic bias, University of Texas at Austin researcher Maria De-Arteaga described a case study she and colleagues had done about bias in crime-reporting statistics and its effect on predictive policing using data from Bogotá, Colombia. (Note: We wish to bring attention to the ongoing police brutality in both Bogotá and Colombia as a whole, where police are violently repressing civilians' protests and disproportionately targeting Black and indigenous communities.)

Predictive policing is increasingly deployed in cities and countries around the world and has come under scrutiny due to a lack of transparency and concern about biased outcomes. One focus of these critiques has been the potential for dangerous feedback loops when using arrest data as a basis of crime prediction. The issue is that the proxy, arrests, may not represent where crimes are being committed due to biases in arrests. In a paper about this phenomenon, Lum and Isaac write, "predictive policing is aptly named: it is predicting future policing, not future crime." They demonstrate that using data on drug arrests in Oakland, California as inputs to the model used by PredPol, one of the large companies providing predictive policing systems, would result in high concentrations of policing in racial and ethnic minority neighborhoods. In another paper, Ensign, et al. used a generalized Pólya urn model to theoretically analyze how feedback loops in arrest-based predictive policing systems arise.

In response, proponents of predictive policing have agreed that there is a concern there but say that they do not use this type of data in their models. PredPol, for example, says that their algorithms are unbiased by nature due to the fact that the data collected and analyzed is primarily victim data. When they do use arrest data, they exclude certain types of drug-related offenses and traffic citation data, which are usually police-initiated, because it is known to reflect officer bias.

In a study conducted in Bogotá, Colombia, Akpinar, De-Arteaga, and Chouldechova demonstrate how differential victim crime reporting can lead to geographical

outcome disparities in hotspot predictions, even when the predictive policing algorithms do not use arrest data. These disparities result in both over- and under-policing. They found that there were large disparities in crime reporting between districts. In one district, Chapinero, 9% of people were victims of a crime, and 28% of them reported it. In Usaquén, 18% of people were victims of a crime, and 13% of them reported it. When trained only on reported crime data, some districts required more than double the crime rate of other districts to be selected as hotspots.

The problem is not confined to the researchers' choice of model, a self-exciting process model, which is being considered for deployment in Bogota and already used by PredPol. They looked at other types of models that are used in predictive policing and found very similar results. Therefore, the problem will be present in any of the predictive policing models currently in use. In summary, differences in victim crime-reporting rates can lead to geographical bias in common hotspot prediction algorithms, even when no data from arrests or police-initiated contact is used. These algorithms can therefore lead to misallocation of police patrols in the form of both over-policing of some neighborhoods and under-policing of others. Victim crime-reporting rates are known to be driven by socioeconomic factors, types of crime, and other demographics. More work is needed for an in-depth discussion of the interplay between predictive disparities and these factors in the Bogotá context.

Fair Division, Allocation, and Representation

The fairness of voting systems is a racial justice issue. In the early history of the U.S., Black people were not allowed to vote at all. After the Civil War, unjust voting laws in many states kept them from exercising that right. Today, the gutting of the Voting Rights Act, the disproportionate number of Black people who cannot vote due to felony convictions—especially for nonviolent drug-related crimes—and congressional districts that distort the will of the people continue to dilute the political power of Black people and other marginalized groups. Stephanie Somersille, founder of Somersille Math Education Services, spoke about the role mathematicians can play in combatting gerrymandering (the process of drawing congressional districts that favor one party) and drawing fairer congressional districts, highlighting a new metric for quantifying gerrymandering that she has been involved in developing.

One of the obstacles to addressing gerrymandering in court is that there is no widely agreed-upon metric defining gerrymandering. The "you know it when you see it" definition of gerrymandering is unsatisfying. Being able to measure the problem is crucial in addressing it.

Currently popular metrics fall into two camps: map data metrics and election data metrics. The map metrics, such as the Polsby-Popper ratio, the Roeck ratio, the convexity coefficient, and the convex hull, are based on the geometric irregularity of the shapes of districts. The Polsby-Popper ratio, for example, is proportional to the ratio of the area of the district to the square of its perimeter. The convexity coefficient is based on the probability that the straight line between any two points in the district is itself entirely contained within the district.

Map data metrics have a few weaknesses. For one, the physical geography of a district influences the metric. A river, mountain range, or coastline can make a district seem gerrymandered when it is not. Furthermore, with modern technology, it is easy to generate thousands of maps with the same score on any metric of interest and choose the one that best suits one's agenda.

Election data metrics, on the other hand, are based on voting patterns in recent elections and tend to assume the existence of two dominant political parties. These metrics include the mean-median difference, efficiency gap, partisan bias metric, and declination function. They include data such as the number of wasted votes — votes for the losing candidate and votes for the winning candidate beyond the majority necessary to win — and comparisons between statewide and district-wide election margins. These metrics can have shortcomings as well, such as flagging proportional outcomes as gerrymandered in regions that are dominated by one party.

Somersille and colleagues have developed a new metric, the Geography and Election Outcome metric (GEO metric), that uses both geography and election data to measure gerrymandering. The basic idea is to look at wasted votes and determine whether swapping some voters with a neighboring district would cause the relevant party to gain an additional seat. (For more details about the metric, see the compendium.)

The GEO metric is promising for several reasons. It is understandable, which is helpful for use in court. It recognizes the importance of both geography and election data in determining whether a district is gerrymandered. Finally, it flags districts for two of the primary forms of gerrymandering: "packing" and "cracking." A politician who is drawing a map in their own interest often "pack" some voters for the opposing party into a few districts that the opposition will win by a large majority and "crack" others into several districts that the map-drawer's own party will win by slim margins.

One new metric for assessing gerrymandering will not solve the problem on its own. Mathematicians who wish

to use their skills and training to work for fairer elections and congressional maps need to develop a strong background in election history and laws in addition to mathematics.

Public Health Disparities

Emma Benn, a statistician at the Icahn School of Medicine at Mount Sinai, spoke about the need for a paradigm shift in the way public health researchers attribute and discuss race and racism as contributors to health outcomes. Every year, researchers publish hundreds of studies that demonstrate race- and ethnicity-related health disparities.

Researchers have the tendency to attribute these health disparities to biological differences between races, but race is a social construct only tenuously rooted in genetics. The fact that study after study finds race/ethnicity-related health differences but that race has little biological meaning creates difficulty in attributing a causal effect to race. Paul Holland, a statistician working for the Educational Testing Service, raised this point in a 2003 paper. He argued that the measured effects of race do not have a causal interpretation. He believed that causes of outcomes should be experiences that individuals undergo, not attributes that they possess. Causal variables themselves must reflect the possibility of manipulation. Skin bleaching and plastic surgery aside, race is not mutable. Race therefore does not fit into an inferential framework, although it may play an important role in causal studies for descriptive reasons. Holland writes, "In my opinion, RACE can play an important descriptive role in identifying important societal differences such as those in wealth, education, and health care. The attribution of cause to RACE as the producer of these differences is, to me, the most casual of causal talk and does not lead to useful action."

Race may play a role as an effect modifier; that is, an intervention or exposure may have a different effect on an outcome across racial/ethnic groups. Findings of that nature can help researchers delve deeper into the effects of discrimination and bias. But many studies stop at race and never delve into naming racism, rather than race, as a cause of health disparities. Unless the amount of melanin in skin can cause an outcome, caution should be used when ascribing a causal role to race rather than to racism or its downstream effects. Furthermore, the overarching goal of medical research is not to describe differences; it is to reduce disease and improve health. So a focus on race as a causal factor is less helpful than a focus on causal factors that can be changed.

If researchers are to move from describing racial differences to identifying mutable targets for intervention, then race cannot be the endpoint. In 2020, the convergence of the COVID-19 pandemic and widespread acknowledgement of the crisis of systemic racism in the U.S. motivated researchers to move beyond individual-level associations between race and health to studies that look at broader systems and structures. When researchers suspect that biological and genetic differences between races may indeed contribute to different health outcomes, genetic ancestry data would be a better variable to include than the more blunt tool of race, as a 2021 article by Akinyemi Oni-Orisan and coauthors argues. They write,

> We do not believe that ignoring race will reduce health disparities; such an approach is a form of naive "color blindness" that is more likely to perpetuate and potentially exacerbate disparities. Although ignoring race could improve *equality* (by leading to identical medical treatment for everyone), we believe that *equity* is necessary to address disparities. We urge our colleagues in medicine and science to refrain from haphazardly removing race from clinical algorithms and treatment guidelines in response to recent initiatives attempting to combat anti-Black racism. The ultimate goal, we believe, would be to replace race with genetic ancestry in an evidence-based manner. But we have not yet reached a point where genetic-ancestry data are readily available in routine care or where clinicians know what to do with these data. Until we do, ignoring race and thereby reverting to the United States' outdated system of health care, in which clinical research findings are generated in populations of European descent and extrapolated to the treatment of non-European populations, is neither equitable nor safe for those other populations.

Racial Inequities in Mathematics Education

Brittany Mosby, the Director of Historically Black Colleges and Universities (HBCU) Success programs and initiatives at the Tennessee Higher Education Commission, spoke about creating mathematics classrooms that are liberatory for students.

Liberatory education is education that becomes "the practice of freedom," to use a term coined by Paulo Freire, educator, philosopher, and author of the book *Pedagogy of the Oppressed*. Liberatory education can be transgressive and disruptive of the status quo in the classroom because its goal is to create beings who are able to change their society, not to create employable workers. Liberatory education is community- and dialogue-centered rather than centered on individualism. It is an anti-oppressive, humanizing pedagogy whose goal is self-actualization, not only of the students but also of their instructors. It engages with the world outside the classroom. To practice freedom

within education requires tearing down the walls between the classroom and the outside world.

Some people use nationalistic aims, whether military or economic, as motivation for increasing the participation of Black and Brown students in STEM fields. Education as the practice of freedom, however, sits in direct opposition to those aims. Instead of focusing on creating people who can produce more and more economic value for the country, liberatory education focuses on creating holistic, lifelong learners who are able to question and challenge society and who have the tools necessary to do so.

There are several key elements of a liberated mathematics classroom. First, it affirms students' existing cultural knowledge and mathematical intuition. Teachers are not overly concerned with pointing out where students are wrong but with working in tandem with them to deepen their knowledge of a subject and work towards more complete understanding.

A liberated mathematics classroom also highlights the utility of mathematics as a language to understand problems across multiple fields. When students ask, "when will I use this" or "why do I need to know this," a teacher should be able to point to the utility of mathematics as one reason. Teachers should be incorporating problems from multiple other fields into their classrooms to demonstrate the versatility and power of the techniques students are learning.

A liberated mathematics classroom encourages metacognition and agency in the learning process. When a teacher is in community with students, the students are able to take responsibility for their learning, which requires them to think about how they are learning and whether they are learning effectively. They should also be equipped to fix problems they have with learning.

A liberated mathematics classroom does not rely solely on lecturing to impart knowledge. This assertion may be the point of biggest pushback on the framework of liberated education because mathematics educators feel so much pressure to get through a large number of learning objectives. Lectures may be necessary sometimes, but even in lectures, students should be engaged, active participants, not empty vessels.

A liberated mathematics classroom balances rote, single-skill practice with complex, contextualized, multistep problems. Fluidity with some rote skills is a helpful, and often necessary, step for students who want to apply mathematics to more complex problems, but even when focusing on rote skills, teachers can incorporate student discovery into the process. For example, instead of merely memorizing the multiplication table, students can find patterns and symmetry in the multiplication and figure out why. Then teachers can incorporate contextualized problems that use multiplication.

Finally, a liberated mathematics classroom is decolonized. It decenters whiteness, maleness, and Europeanness. It introduces students to non-Western foundations of mathematics, such as those in the Arab world and Africa, and includes the history of women's contributions to mathematics.

A classroom where mathematics is the practice of freedom is a classroom that centers mathematics as a process of discovery. The mathematics classroom is a place of collaboration, among students, between students and instructors, and between the students and the content as co-creators of that content. Rather than being overly concerned with smacking down wrong ideas, it empowers students along their journeys. This process is radical and often uncomfortable, sometimes even to students, who may be used to being passive recipients of information rather than active co-creators.

Conclusion

Historically, mathematics has been used as both an instrument of oppression and an instrument of liberation; mathematics education has reinforced racial hierarchies, but it has also been a gateway for freedom and opportunity. Algorithms and statistics can perpetuate or identify and mitigate racism; mathematical tools can be used to create fairer elections or entrench unjust power dynamics. Mathematics has a role to play in today's movement for racial justice, and mathematicians can choose how to use their skills to advance justice. The speakers at the MSRI Workshop on Mathematics and Racial Justice showed how they use their expertise in a broad range of mathematical fields, including geometry, statistics, and data science, to document injustice and develop solutions for it. Using their presentations as jumping-off points, participants joined breakout rooms to generate ideas and concrete plans to take action in their own classrooms and communities. For example, participants who focused on bias in algorithms and technology proposed the development of an "FDA for algorithms," outlining the way such a regulatory body could prevent harmful algorithms from being employed in high-stakes decisions affecting consumers and citizens, while participants in the room dedicated to public health discussed working with hospitals, NGOs, and universities conducting medical research to provide support for more robust and complex studies of racial disparities in health. For a more detailed exposition of the topics addressed in the workshop, see the workshop compendium: `http://library.msri.org/msri/Math-and-Racial-Justice.pdf`.

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