Quantifying Brown: Challenges, Models and Approaches

# Abstract

The practice and process of quantification involves the measurement or numerical expression of attributes related to a specific phenomenon, event, or entity. This article takes a critical quantitative approach to school desegregation on this 70th anniversary of *Brown*. The analysis engages a 1974 article by Michael Giles in the *Journal of Negro Education* titled “Measuring School Desegregation,” where a segregation index is used to quantify the “movement” of Black children and youth across schools in a district to help fulfill the perceived promise of *Brown*. In the present study, I conduct a critical conceptual replication of Giles’ work that incorporates research at the intersections of critical theory, Black education, and educational studies. The replication and analysis reveal much of what is known about quantitative applications to complex phenomenon, namely that seemingly comprehensive models and technical language do not fully account for the social, historical and political systems associated with school desegregation. An extension to contemporary perspectives on critical quantification, however, present a series of examples that can be leveraged to frame the failure of public policies. The need for extending current discussions at the intersection of critical theory and quantification beyond general linear models and related statistical analyses to include spatial data and what is termed as the *topological properties of anti-blackness* in education is described.

Keywords: *Brown v. Board of Education*, segregation, race, modeling, anti-blackness

# Introduction

This paper considers the 1954 United States’ legal case of *Brown vs Board of Education of Topeka* (States, 2004) to examine the conditions under which quantification and anti-blackness in a geopolitical lens might be used to extend perspectives on mathematical modeling in relation to issues of racial injustice in relation to racialized toplogical structures of neighborhoods and schools. Racialized topological structures (RTS) refer to the persistent patterns of racial inequality and segregation that are embedded within and reproduced by organizational and social systems, independent of individual intent. These structures can be understood as a network of interconnected racial schemas, rules, and resources that shape the distribution of power, opportunities, and outcomes across different racial groups, maintaining racial hierarchies even as surface-level policies or practices may change over time. Prior work across disciplines has made use of mathematical models around issues of justice, and specifically those issues that impact specific groups, such as those racialized as Black within the legal context of the United States (Darity Jr & Mullen, 2022; Lobo et al., 2019). This paper argues that while traditional approaches to mathematical modeling often fail to attend to the complex and dynamic features of the social, economic, cultural, and geopolitical histories that help researchers make better sense of variations in how racism manifests, mathematical modeling in a critical quantitative framework may offer some important entry points and counterexamples to aid our thinking about the function of anti-blackness in education, but also in global society more broadly.

While urging readers to consider the role of a mathematical model, and the practice of defining terminology and variables to make sense of but not meditate on the nuances and differences that drive much of the contemporary scholarship and methodological approaches in the humanities and social sciences, this papers generates a set of considerations around the role and function of postulates and measurement ranges in mapping sociological theories to mathematics – much in the tradition of mathematical sociology. Mathematical sociology is an interdisciplinary field that uses mathematical tools and models to understand, analyze, and predict social phenomena. It involves applying mathematical techniques to formulate sociological theories and model social interactions and structures around some of the intuitive realities than can be done more precisely through qualitative methods. In mathematical sociology, an attempt is made to take theory and intuition to define some parameters more formally. In the expanding of tradition of critical quantitative practice, this article asks what the potential pitfalls are and the possibilities of extending mathematical modeling to issues of segregation and desegregation beyond what is currently provided in the research literature.

The primary aim of this paper is to consider a set of questions around the potential benefits, challenges, and pitfalls of using various measures of segregation to analyze and understand the persistence of antiblackness in the United States education system. To address this question, I present a set of postulates for framing segregation, followed by a set of conditions focused on race across the various multiscale and historical dimensions in the quantification of segregation. I then discuss the added benefit of extending current discourses in quantitative critical theory to include critical spatial data analysis and describe some of the *topological properties of anti-blackness* in U.S. education.

# Conceptual Framework

Derrick Bell’s *Silent Covenants* (Bell, 2004) speaks on the involuntary sacrifices and racial convergences that encode the ongoing realities of inequitable and unjust public policies in the United States. Taking a critical historical approach to the ongoing inadequacy of racial policies, Bell challenges readers to consider nuance in narratives of hope and trust and in policies that can be historically mapped by failed progress. Bell considers legal cases to outline how these failures have been maintained “throughout the history of civil rights policies,” which he notes, “have been insufficient…to gain real relief from any branch of government” (p. 49). When considering the injustices that Black people in the United States have and continue to suffer, Bell renders the long shadow of *Plessy* to pathways beyond the ideation of racial fortuity – or the condition where Black people’s lives are subject to change, at the interplay of interest convergence and racial sacrifice. Here, with racial fortuity, Bell provides an intersectional class critique, connecting to the theme of materialism in his broader work, and challenges, as I argue, scholars to consider how our interests, rather than our moral considerations, drive much of our willingness to not only witness but to *advocate* and *allow* for the subjugation of certain Black children, youth, and families in the United States’ educational systems (Dumas, 2014; Dumas & Ross, 2016; Miraya Ross & Givens, 2023). This article takes a critical quantification approach to extend, in essence, one of James Baldwin’s famous quotes around progress. In 1989, the American writer, when considering, like Bell and other scholars (2014), the history of systemic racism and failed progress in U.S. public policies asked: “You always told me it takes time. It has taken my father’s time, my mother’s time, my uncle’s time, my brothers’ and my sisters’ time, my nieces’ and my nephews’ time. How much time do you want for your ‘progress’?”

There are extensive resources, archival records, and research studies on *Brown* (Chestnut & Chestnutt, 2004). These resources take theoretically and methodologially different approaches to develop a series of concepts through which they analyze the conditoins surrounding the decision. Giles (1974) notes that “despite the fact that legal and administrative decisions concerning school desegregation have rested increasingly on quantitative concepts, little attention has been directed toward the development of a uniform and rigorous method for measuring school desegregation (p. 516). The purpose his article was to suggest a measure but, in doing so, much of the social contexts was left to be desired. The introduction of advanced quantitative inquiries and computational technologies allows us to extend the specificity lacking in Giles’ study. For example, (Chodrow, 2017) notes that we should “view the problem of learning the structure of segregation as the task of ﬁnding interpretable units of spatial aggregation with boundaries that correspond to demographic transitions. This problem is a form of regionalization—spatially constrained clustering” (p. 11592). When taken in the context of educational theories, however, we are challenged to consider the role of critical theories in advanced analytic techniques within social and historical realities of inequity in the diverse narratives on Black education (King, 2006; Miraya Ross & Givens, 2023; Tillman, 2008).

## QuantCrit

QuantCrit (Quantitative Critical Race Theory) is an expanding analytical framework that applies Critical Race Theory principles to quantitative research methods and data analysis (Garcia et al., 2018; Gillborn et al., 2023). It challenges traditional approaches to quantitative research, particularly in education and social sciences, by critically examining the assumptions, biases, and power structures embedded in statistical methods and interpretations. The five key principles of QuantCrit include: recognizing the centrality of racism in society, acknowledging that numbers are not neutral, understanding that categories are socially constructed, emphasizing that data cannot “speak for itself,” and maintaining a social justice orientation (Castillo & Gillborn, 2022; Gillborn et al., 2023). QuantCrit encourages researchers to critically examine their research questions, variable construction, and analytical choices, while considering how racism and other forms of oppression might be revealed through differential outcomes in statistical analyses (Suzuki et al., 2021).

The application of QuantCrit extends beyond education to fields such as medicine and literature, demonstrating its interdisciplinary potential (Castillo & Babb, 2024). Researchers using QuantCrit are encouraged to use intersectional approaches that account for multiple, simultaneous identities, challenge traditional interpretations of statistical significance and effect sizes, and contextualize findings within broader historical and social contexts of inequality (Srinivasan et al., 2024). Importantly, QuantCrit is not just about applying critical principles at the end of a study, but about integrating critical perspectives throughout the entire research process, from conceptualization to dissemination of results (Castillo & Gillborn, 2022). This approach represents a growing movement to make quantitative research more equitable, contextualized, and oriented towards social justice, while also acknowledging the researcher’s own positionality and potential biases in data interpretation (Tabron & Thomas, 2023).

## BlackCrit

Black critial theory (Dumas & Ross, 2016), however, challenges some of the burgeoning notions of QuantCrit (Toldson, 2019; Turner, 2023). These challenges are present in both the reliance on CRT as a theory of Black people and considerations about the burgeoning notions of Black educational studies (BES) (Miraya Ross & Givens, 2023). This approach should challenge methodological inquiries around the methods that can be used to push beyond contemporary narratives and move towards those that can increasingly provide opportunities to discuss, in relation to the abolitionist tradition, the expanding willingness to allow for some Black children to thrive but not *all* Black children (Love, 2019). These extensions also challenge us to refuse a singular focus, for example, within research on the social and emotional learning for Black and other children racialized as non-white (Camangian & Cariaga, 2022) in the case for teaching and learning; but examine the systems to which sit at the root of why broader and multi-level systems are not the issue in all modern analyses of schools and schooling. We argue that a theoretical entry into doing so begins with the inclusion of modern computational tools around critical and abstract understandings of quantitative approaches.

## Quantifying Desegregation

Importantly, scholars have taken on different approaches to discussions of *Brown*. In some instances, scholars utilizes the term ‘segregation’ to relay the various historical features of how neighborhoods and schools have been segregated by race. In other instances, scholars’ approaches have considered the various mechanisms through which public policies might respond to this segregation. These differences provide an important theoretical split in potential critical quantitative approaches to the question of advancing equity in the context of policies that uptake critical theories of race; that is, CRT, BlackCrit, and BES. In each of these frames, scholars deal more acutely with the extensions of critiques that position, increasingly, history as a central component to how we think about moving public policies forward to consider the value of Black children in America’s schools, especially as secondary and postsecondary policies increasingly prevent districts and educational institutions from considering race as a central feature to the spatial features of modern analysis. Additionally, with the availability of new computational tools, there is added opportunity to take into serious consideration the ways that prior evidence in both qualitative and quantitative research pushes us to ask, again returning to Bell (1991, 2004), around the reality and positionality of Black people in society, and Dumas (2014, 2016).

# Analytic framework

To advance the theoretical framework for the study, we use mathematical logic as an analytic approach to framing the conceptual replication of the study initially conducted by Giles in his 1974 article in the *Journal of Negro Education* (Giles, 1974). Giles’ work centered on the value of a model, the Index of Dissimilarity, in supporting researchers at the time in making sense of the various political contexts surrounding school desegregation. His analyses contributed to the discourses at the time a quantitative application of the ongoing racism encountered following *Brown v. Board*. In the current analyses, we consider the contemporary literature on Black education and critical quantitative approaches to consider the narratives that might allow us to examine, similar to Bell’s analysis in *Silent Covenants* (Bell, 2004), and his related work on the *permanence* of how Black people experience racism.

### Specificity versus generalization

We begin the conceptual replication with a critical theory to advance the analytic framework and the difference between specificty and generalization. This framing, between how specific we would like to be versus how general we’d like to describe a social process *begins* the act, at least in the existing framework, of scale that informs the use of a set of values across a range of possible inputs. These inputs inform the model’s outputs and can be used to generate a set of focal points – we use the conceptual replication as one example of how this occurs in the analysis provided by Giles. The act of specificity versus generalization is inserted the stated or standard assumptions about race and racism that have been prioritized in not only the discourses mentioned but the parameter of the models.

When we take an opportunity nto consider the increasing and important specificity of contemporary scholarship regarding scholars’ approaches to the analysis of student level data, I examine how Giles’ work on the index of dissimilarity provides a set of important inquiries to the ongoign attempts to improve modeling in relation to *Brown*. Namely, I argue that a wholesale dismissal of these attempts is neither productive or scholarly in nature. I also also argue that for some extensions, however, their theoretical starting points may inform a wholesale dismissal. In this case, however, an “honest” approach to making sense of the model (and not simply the methodological focus) brings us to current approaches in QuantCrit.

This paper also argues that conversations on critical quantification are missing in relation to the analysis of spatial data, with some notable exceptions across different disciplines (cite Ortiz, luriel, other spatial scholars). The spatial aspects of these questions relate to a sample inquiry with the index of dissimilarity and the ultimate expansnion to other highly information indices, as noted by Chodrow (2017), which can be useful for in the analysis of contextual data. Importantly, however, this paper takes a particular approach to ensuring that the modeling process and value for the lay reader, is prioritized over the traditional aims of scientific study, which may not be in alignment with community-focused scholarship. Here, I define community-focused scholarship that takes seriously the value of research for the common good but in ways that are useful to the general public so as to inform a more engaged inquiry with contemporary scholarship. Mathematics is considered as an important feature to the public’s understanding how anti-blackness functions.

### Segregation versus desegregation

Importantly, scholars have taken on different approaches to discussions of *Brown*. In some instances, scholars utilizes the term ‘segregation’ to relay the various historical features of how neighborhoods and schools have been segregated by race. In other instances, scholars’ approaches have considered the various mechanisms through which public policies might respond to this segregation. These differences provide an important theoretical split in potential critical quantitative approaches to the question of advancing equity in the context of policies that uptake critical theories of race; that is, CRT, BlackCrit, and BES. In each of these frames, scholars deal more acutely with the extensions of critiques that position, increasingly, history as a central component to how we think about moving public policies forward to consider the value of Black children in America’s schools, especially as secondary and postsecondary policies increasingly prevent districts and educational institutions from considering race as a central feature to the spatial features of modern analysis. Additionally, with the availability of new computational tools, there is added opportunity to take into serious consideration the ways that prior evidence in both qualitative and quantitative research pushes us to ask, again returning to Bell (1991, 2004), around the reality and positionality of Black people in society, and Dumas (2014, 2016).

### Between-school versus within-school segregation

Between-school segregation refers to the uneven distribution of students from different racial or ethnic groups across schools within a district or larger geographic area. This type of segregation occurs when students of different races or ethnicities are concentrated in separate schools. It often reflects residential segregation patterns and can result from school assignment policies, school choice programs, or demographic shifts. Between-school segregation is typically measured by comparing the racial/ethnic composition of individual schools to that of the overall district or area. This form of segregation can lead to significant disparities in educational resources, teacher quality, and academic outcomes across schools, perpetuating broader societal inequalities. Within-school segregation, also known as classroom-level segregation, refers to the uneven distribution of students from different racial or ethnic groups across classrooms or academic programs within the same school. This type of segregation can occur even in schools with diverse overall student populations and is often associated with academic tracking or ability grouping practices. Within-school segregation is measured by comparing the racial/ethnic composition of individual classrooms or programs to that of the overall school. It can result in students from different racial or ethnic backgrounds having vastly different educational experiences and opportunities, even while attending the same school.

Both types of segregation are typically measured using indices like the Index of Dissimilarity, which quantifies the degree of unevenness in the distribution of different groups. Importantly, research has shown that these two forms of segregation can be inversely related. As studies have found, when between-school segregation decreases (i.e., schools become more racially diverse), within-school segregation often increases. This suggests that efforts to integrate schools at the district level may sometimes lead to increased separation within those schools, potentially through mechanisms like academic tracking or course selection patterns. Understanding both between-school and within-school segregation is crucial for developing comprehensive strategies to promote educational equity and true integration in school systems.

## Mathematical Method

To inform our use of the model, I begin by establishing a set of focus contexts and conditions related to *Brown* and use them to discuss the Index of Dissimilarity and school-level segregation. These postulates will serve as a foundation to the assumptions for analyzing the impact of the decision and its relationship to quantifying segregation. These are as follows: (1) Despite the Brown v. Board of Education decision declaring state-mandated segregation of public schools unconstitutional, segregation has continued for at least 70 years or more, (2) de jure segregation was officially ended within policies by the decision, but de facto segregation persists due to various socioeconomic factors, (3) residential patterns significantly influence school attendance zones and, consequently, school composition, (4) the Index of Dissimilarity (D) can be applied to measure school segregation levels, similar to its use in residential segregation studies, and (5) a decrease in the Index of Dissimilarity over time would indicate progress towards desegregation in schools. I then use these postulates to apply to the modified Index of Dissimilarity.

## Model

Standard geospatial measures of segregation, such as the Index of Dissimilarity (D), inherently assume the movement of Black youth, children, and families to achieve desegregation, reflecting an underlying anti-Black bias in its formulation and application to school desegregation efforts. For the conceptual replication, we consider a slightly modified Index of Dissimilarity (D) as to what is outlined in (Giles, 1974):

D represents the index of dissimilarity itself, which ranges from (complete integration) to (complete segregation). The summation symbol () indicates that we’re adding up values across all geographic units, from to , where is the total number of units (e.g., neighborhoods or census tracts) in the area being studied. The variable represents the population of group in the th geographic unit, while is the total population of group A in the entire area. Similarly, is the population of group B in the ith unit, and B is the total population of group B in the whole area. The vertical bars || denote the absolute value, ensuring that negative differences are treated as positive. The fraction 1/2 at the beginning of the formula adjusts the final result to calculate the average difference in the proportional distribution of the two groups across all geographic units, providing a measure of how unevenly the groups are distributed relative to each other.

Some important limitations of the model exist in relation to issues of measurement, interpretation, thresholds, temporal and comparative analysis, and policy evaluations. The Index of Dissimilarity for schools would compare the distribution of two groups (e.g., Black and White students) across different schools within a district or larger geographic area. The resulting D value would range from 0 (complete integration) to 1 (complete segregation), often expressed as a percentage. Values between 0 and 30% indicate low segregation, 31-60% indicate moderate segregation, and 61-100% indicate high segregation. By calculating D for different years, we can track changes in school segregation levels over time, potentially revealing the long-term effects of the Brown v. Board of Education decision. The Index allows for comparisons between different school districts or regions, helping identify areas where desegregation efforts have been more or less successful. Changes in D can be used to assess the effectiveness of various desegregation policies implemented in the wake of the Brown decision. It is important to note that while D measures evenness of distribution, it doesn’t account for other factors like the quality of education or within-school segregation.

The index represents the proportion of Black students that would need to move to different schools to achieve an even distribution relative to White students. The formula implicitly assumes that to reduce D, the numerically smaller group (typically Black students in many contexts) would be the one to move. In the context of school desegregation following *Brown v. Board of Education*, the burden of movement has historically fallen on Black students, often through busing programs. By implicitly suggesting the movement of the minority group (Black students), the index reinforces existing power dynamics and fails to challenge the centrality of whiteness in educational spaces. The index focuses on numerical distribution without addressing underlying systemic issues that lead to segregation, such as housing policies, economic disparities, and institutional racism4.

# Analysis

Unlike Giles, this critical conceptual replication uses a data-informed approach to consider the various metrics through which we might consider measuring segregation. In his work, Giles discuss the various schooling contexts that will help “[determine] what condition or conditions constitute desegregation for a school district” (Giles, 1974, p. 518). He considers the issue of voluntary of involuntary mandates for desegregation follow *Brown*. As discussed in the recent publications provided by the Spencer Foundation on the 70th anniversary of Brown, the dynamic conditions which constitute a consideration of *Brown’s* promise require a complex analytic approach. Education researchers have taken on various models to consider the various complexities involved in modeling desegregation. For example, Reardon & Owens (2014), considering the 60th anniversary of *Brown* analyzes various trends in the quantification of school segregation.

## State-level data on two-group dissimilarity

The data on North Carolina based on the provided metric returns the Charlotte, NC-SC urban area and the Raleigh region.

## # A tibble: 2 × 3  
## # Groups: urban\_name [2]  
## urban\_name stat est  
## <chr> <chr> <dbl>  
## 1 Charlotte, NC--SC Urbanized Area (2010) D 0.571  
## 2 Raleigh, NC Urbanized Area (2010) D 0.438

The data on Illinois based on the provided metric returns the Chicago, IL-IN and St, Louis, MO-IL urban regions.

## # A tibble: 2 × 3  
## # Groups: urban\_name [2]  
## urban\_name stat est  
## <chr> <chr> <dbl>  
## 1 Chicago, IL--IN Urbanized Area (2010) D 0.748  
## 2 St. Louis, MO--IL Urbanized Area (2010) D 0.561

The data on Texas returns six urban areas: McAllen, Houston, Dallas-Fort Worth-Arlington, Austin, San Antonio, and El-Paso, TX-NM regions.

## # A tibble: 6 × 3  
## # Groups: urban\_name [6]  
## urban\_name stat est  
## <chr> <chr> <dbl>  
## 1 McAllen, TX Urbanized Area (2010) D 0.670  
## 2 Houston, TX Urbanized Area (2010) D 0.589  
## 3 Dallas--Fort Worth--Arlington, TX Urbanized Area (2010) D 0.557  
## 4 Austin, TX Urbanized Area (2010) D 0.487  
## 5 San Antonio, TX Urbanized Area (2010) D 0.454  
## 6 El Paso, TX--NM Urbanized Area (2010) D 0.370

The data on California returns six regions: Los Angeles, San Francisco, Sacramento, San Diego, San Jose, and Riverside-San Bernadino.

## # A tibble: 6 × 3  
## # Groups: urban\_name [6]  
## urban\_name stat est  
## <chr> <chr> <dbl>  
## 1 Los Angeles--Long Beach--Anaheim, CA Urbanized Area (2010) D 0.646  
## 2 San Francisco--Oakland, CA Urbanized Area (2010) D 0.603  
## 3 Sacramento, CA Urbanized Area (2010) D 0.530  
## 4 San Diego, CA Urbanized Area (2010) D 0.514  
## 5 San Jose, CA Urbanized Area (2010) D 0.467  
## 6 Riverside--San Bernardino, CA Urbanized Area (2010) D 0.446

## Data across multiple groups

One concern cited about the dissimilarity index is that it only measures segregation between two groups, and that those two groups tend to be based on a comparison of Black and white children. There are also concerns around economic segregation that require additional concepts to inform our mathematical model. Owens et al. (2014) consider trends in economic segregation of schools that could inform a theoretical inquiry into possible intersections with different models. These considerations essentially call for a more focused analysis in QuantCrit in education on the diversity of Black children and youth, and the importance of the historical features of that diversity, as discussed by Miraya Ross & Givens (2023), which challenges ongoing approaches to issues of race which group Black students in a monolith framing. If this inquiry is enacted upon, two such cases exist as a possible start:

Entropy-based segregation indices are statistical measures that quantify the level of segregation between groups in a population by utilizing the concept of entropy from information theory. The Mutual Information Index (M) and Theil’s Information Index (H) are entropy-based segregation measures that can be calculated using R. These indices capture segregation as the extent to which groups have different distributions across units (e.g., schools or neighborhoods) compared to the overall population distribution. For a dataset T, M is computed as:

Here, is the total number of units , is the total number of groups , and is the joint probability of being in unit and group , with and referring to unit and group probabilities, respectively. Theil’s for the same dataset can then be calculated as:

where is the entropy of , normalizing to range between values of and (Walker, 2023). These functions allow for the calculation of both and indices, providing comprehensive measures of segregation that account for multiple groups and units simultaneously.

The index measures the average change in entropy when moving from the overall population distribution to the distribution within each unit, while the index is a normalized version of . These indices possess desirable properties including decomposability, allowing for the analysis of segregation at multiple levels (e.g., local and global) and across different dimensions (e.g., within and between groups). Entropy-based indices provide a nuanced approach to measuring segregation that can account for multiple groups simultaneously and offer insights into the information content of group distributions across units (Frankel & Volij, 2011; Mora & Ruiz-Castillo, 2011).

#### North Carolina

The North Carolina regions are as follows:

## Key: <urban\_name>  
## urban\_name M p H  
## <char> <num> <num> <num>  
## 1: Charlotte, NC--SC Urbanized Area (2010) 0.2409498 0.5615239 0.2218418  
## 2: Raleigh, NC Urbanized Area (2010) 0.1795516 0.4384761 0.1751563  
## ent\_ratio  
## <num>  
## 1: 1.0218128  
## 2: 0.9643875

#### Illinois

Illinois urban regions are as follows:

## Key: <urban\_name>  
## urban\_name M p H  
## <char> <num> <num> <num>  
## 1: Chicago, IL--IN Urbanized Area (2010) 0.4425177 0.95277672 0.3741865  
## 2: St. Louis, MO--IL Urbanized Area (2010) 0.2468198 0.04722328 0.3157410  
## ent\_ratio  
## <num>  
## 1: 1.0084688  
## 2: 0.6666055

#### Texas

The Texas regions are as follows:

## Key: <urban\_name>  
## urban\_name M  
## <char> <num>  
## 1: Austin, TX Urbanized Area (2010) 0.16518058  
## 2: Dallas--Fort Worth--Arlington, TX Urbanized Area (2010) 0.28993837  
## 3: El Paso, TX--NM Urbanized Area (2010) 0.08341730  
## 4: Houston, TX Urbanized Area (2010) 0.29598045  
## 5: McAllen, TX Urbanized Area (2010) 0.05178279  
## 6: San Antonio, TX Urbanized Area (2010) 0.17116796  
## p H ent\_ratio  
## <num> <num> <num>  
## 1: 0.10238862 0.1538095 0.9066899  
## 2: 0.34500728 0.2367665 1.0338755  
## 3: 0.04666088 0.1478314 0.4764007  
## 4: 0.33663553 0.2359761 1.0589557  
## 5: 0.04863604 0.1664257 0.2626927  
## 6: 0.12067165 0.1774318 0.8144676

#### California

The California regions are as follows:

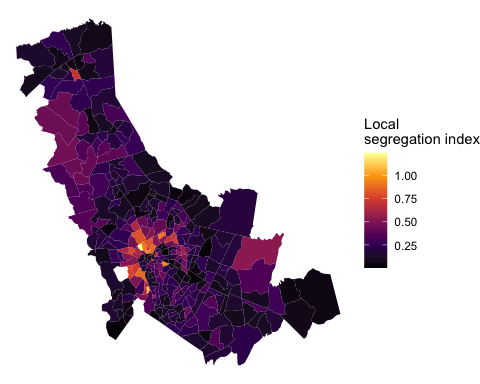
## Key: <urban\_name>  
## urban\_name M  
## <char> <num>  
## 1: Los Angeles--Long Beach--Anaheim, CA Urbanized Area (2010) 0.3391033  
## 2: Riverside--San Bernardino, CA Urbanized Area (2010) 0.1497129  
## 3: Sacramento, CA Urbanized Area (2010) 0.1658898  
## 4: San Diego, CA Urbanized Area (2010) 0.2290891  
## 5: San Francisco--Oakland, CA Urbanized Area (2010) 0.2685992  
## 6: San Jose, CA Urbanized Area (2010) 0.2147445  
## p H ent\_ratio  
## <num> <num> <num>  
## 1: 0.50163709 0.2851662 0.9693226  
## 2: 0.08678082 0.1408461 0.8664604  
## 3: 0.07369482 0.1426804 0.9477412  
## 4: 0.12560720 0.2025728 0.9218445  
## 5: 0.13945223 0.2116127 1.0346590  
## 6: 0.07282785 0.1829190 0.9569681

## Modeling local segregation indices

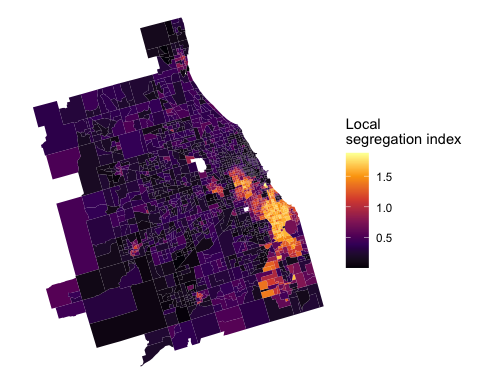
Giles (1974) identifies a set of percent point that serve as measures of desegregation. He provides notes in his original study around the use of different percentation points. The 90-percent point, for example, is defined as “90 per cent or more whites” (Giles, 1974, p. 518) where enrollment points that defined desegregation were provided in The Allen Report of 1964 (Relations, 1964); here the 90 percent point was also used by the HEW’s Office of Civil Rights (Bullock III & Stewart Jr, 1984; Giles, 1975). I use the averages from the education data to generate a series of geographic conditions for variations in segregated school systems.

Table X presents a Sample Segregation Index Model, illustrating the calculation of a segregation index across five schools (A through E). The table contains columns for White Enrollment, Non-White Enrollment, and the Difference between the proportions of each group. It shows the distribution of 2500 White and 2500 Non-White students across the schools. School A has 500 White and 100 Non-White students, while School B has 0 White and 500 Non-White students, demonstrating varying levels of racial composition. The Difference column calculates the absolute difference between each school’s proportion of the total White population and its proportion of the total Non-White population. The sum of these differences (1.40) is then divided by 2 to obtain the Segregation Index of 0.70. This index, ranging from 0 (perfect integration) to 1 (complete segregation), provides a measure of the overall level of segregation across the school system, with 0.70 indicating a relatively high degree of segregation in this sample.

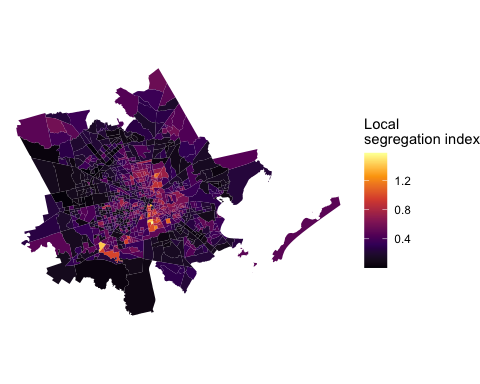
**[Insert Charlotte plot here]**



**[Insert Chicago plot here]**



**[Insert Houston plot here]**



Given the size and diversity of the LA region, I use this as an opportunity to replicate one of the tables identified in (Giles, 1974).

Possible model extension based on LA metrics

| Region | White Enrollment | Non-White Enrollment | Difference |
| --- | --- | --- | --- |
| A | 500 | 500 | .00 |
| B | 500 | 500 | .00 |
| C | 500 | 500 | .00 |
| D | 500 | 500 | .00 |
| E | 500 | 500 | .00 |
| Total | 2500 | 2500 | 0.00 |
| Segregation Index |  |  | .00 |

# Discussion

The topological structure of U.S. educational spaces refers to the fundamental organization and relationships between different elements within the education system that remain invariant under continuous transformations. This structure encompasses the interconnections between schools, districts, and other educational entities, as well as the spatial and relational aspects of learning environments. Topological properties, in this context, are the characteristics of these educational spaces that persist regardless of deformations or changes in scale, such as connectivity, compactness, and the presence of boundaries or “holes” in the system.

In the U.S. education system, we can consider several topological properties. The connectivity of the system is evident in how schools are linked within districts and how districts are connected at state and national levels. The multi-spatial nature of learning contexts, as highlighted in the research, forms a complex topology where physical and digital spaces intersect and overlap. This creates a non-linear, multidimensional structure where learning activities emerge from the relationships between various actants, including physical spaces, digital platforms, devices, educators, and students.

The boundaries in this topological space are often fluid, with the distinction between “real” and “digital” becoming increasingly blurred. This is particularly relevant when considering the concept of learning spaces as contingent assemblages of human and non-human actors. The topology of U.S. educational spaces also exhibits certain “holes” or gaps, which may represent disparities in resource distribution, access to quality education, or segregation patterns.

Analyzing the topological properties of educational spaces can provide insights into persistent issues like segregation. For instance, the distribution of students across schools and districts forms a complex topological structure that can be studied using measures of dissimilarity or other segregation indices. These measures help reveal the underlying patterns of connectivity and separation within the educational landscape.

Understanding the topological structure and properties of U.S. educational spaces offers a framework for examining how changes in one part of the system might affect others, and how certain educational inequities persist despite surface-level transformations. This approach allows researchers and policymakers to consider the relational aspects of education, moving beyond simple geographic or demographic analyses to understand the deeper, more persistent structures that shape educational experiences and outcomes.

## RTS: The topology of anti-blackness in U.S. education

RTS (racialized topological structures), and the specific topology of anti-blackness in the U.S. education systems, suggests an examination of the structural and spatial characteristics of anti-Black racism within the educational landscape of the United States. This perspective aligns with the concept of topology in mathematics, which studies properties that remain unchanged under continuous deformations. In the context of anti-Blackness in education, this topological approach would focus on the persistent, interconnected nature of racial inequities that maintain their fundamental structure despite surface-level changes or reforms.

Postulates are foundational statements in logical and mathematical systems, often used interchangeably but with subtle distinctions. Axioms are generally considered self-evident truths that require no proof, while postulates are assumptions specific to a particular theory or context that are accepted without proof for the purpose of subsequent reasoning. In the development of formal social theories for mathematical inquiry, postulates can be particularly useful. They allow researchers to establish specific assumptions about social phenomena, human behavior, or societal structures that may not be universally self-evident but are necessary for building a coherent theoretical framework. By clearly stating these postulates, social scientists can create mathematical models that quantify and analyze complex social dynamics. For instance, a postulate in social network theory might assume that individuals are more likely to form connections with those who share similar attributes. This assumption, while not universally true, provides a starting point for developing mathematical models of network formation and evolution. Postulates in social theories thus bridge the gap between abstract mathematical concepts and the nuanced realities of social systems, enabling rigorous analysis and prediction of social phenomena through mathematical means. While more advanced analyses may follow (Chodrow, 2017) to consider the ways that complex information may inform our insights about framing a measure of dissimilarity in residential segregation to a measure of schools and students, we develop a set of foundational tools to examine the function in this case.

Developing a set of postulates to explain the topological structure of anti-Black systems in the U.S. involves identifying fundamental principles that govern how anti-Blackness manifests and persists across various educational spaces and contexts. Prior frameworks by scholars have been used to consider some of the foundations and possibilities in relation to Black youth (Bullock et al., 2012; Martin, 2011) and considerations around mathematical methods (Shulman, 1996). The presented axioms might address concepts such as the connectivity of discriminatory practices across different levels of the education system, the persistence of racial segregation despite policy changes, the formation of boundaries that limit opportunities for Black students, and the multidimensional nature of anti-Black practices embedded in curriculum, discipline policies, and resource allocation. These postulates provide a theoretical foundation for understanding how anti-Blackness in education maintains its core features while adapting to different contexts, much like how topological properties remain invariant under continuous transformations.

* **Postulate 1 (Boundary formation)**. Anti-Blackness manifests in the formation of topological boundaries within educational spaces, creating distinct regions of resource allocation, opportunity, and academic tracking that disproportionately disadvantage Black students.
* **Postulate 2 (Persistence under transformation)**. The topological structure of anti-Blackness in education systems remains invariant under superficial policy transformations, preserving fundamental inequities despite changes in educational rhetoric or surface-level reforms.
* **Postulate 3 (Multidimensional embedding)**. Anti-Blackness is embedded in multiple dimensions of the educational topology, including physical space, curriculum, pedagogy, and disciplinary practices, creating a complex network of interconnected challenges for Black students.
* **Postulate 4 (Temporal persistence)**. The topological structure of anti-Blackness in education demonstrates temporal persistence, maintaining core features across generations despite changes in legal and social contexts.
* **Postulate 5 (Scalar invariance)**. Anti-Blackness manifests at multiple scales within the educational topology, from individual classrooms to district-wide policies, exhibiting similar structural properties across these different levels of analysis.

Extensions of these postulates should also consider the intersectionality of oppression as well as the concept of fugitive spaces in education (Givens, 2021). The topological structure of anti-Blackness intersects with other forms of oppression, creating compound effects at the intersection points that disproportionately affect Black students with multiple marginalized identities. Within the broader anti-Black educational topology, there exist sub-altern spaces of resistance and affirmation, known as “fugitive spaces,” where Black educational experiences can be reimagined and cultivated[^1] [Miraya Ross & Givens (2023); (Givens, 2016; Givens & Ison, 2023). These topological properties extend beyond individual schools and boundaries and encompasses formations of digital, social, and virtual space.

[^1] It is beyond the focus of this paper to outline the specific ways in which these processes occur. I encourage the reader to consult the original manuscripts for additional details]

# Conclusion

The topology of U.S. educational spaces is deeply intertwined with the persistent presence of anti-blackness, creating a complex structure that perpetuates inequalities and marginalization of Black students. This topological structure is characterized by interconnected systems of schools, districts, and policies that, despite surface-level changes, maintain fundamental inequities. The persistent nature of anti-blackness within this topology is evident in the way it shapes the experiences of Black students across various educational settings, from urban to suburban and rural areas.

Within this topological framework, anti-blackness manifests in multiple dimensions. At the macro level, it is embedded in policies and funding structures that systematically underfund schools serving predominantly Black communities. This creates “holes” in the educational landscape where resources and opportunities are scarce. At the meso level, anti-blackness is reflected in the segregation patterns that persist within and between school districts, forming boundaries that isolate Black students from educational resources and diverse learning environments. At the micro level, it permeates classroom interactions, curriculum choices, and disciplinary practices that often devalue Black students’ experiences and potential.

The connectivity of anti-blackness within this topology is particularly insidious. It creates a network of interconnected challenges that reinforce each other, making it difficult to address any single issue in isolation. For instance, the underfunding of schools in Black communities connects to lower teacher retention rates, which in turn affects the quality of education available to Black students. This interconnections extends to how anti-blackness influences tracking systems, gifted and talented programs, and special education placements, often resulting in the disproportionate sorting of Black students into lower academic tracks.

Moreover, the topological properties of anti-blackness in educational spaces exhibit a certain invariance under transformations. Despite various reform efforts and policy changes over the years, the fundamental structure of anti-blackness persists, adapting to new contexts while maintaining its core impact. This is evident in how desegregation efforts have sometimes led to new forms of within-school segregation, or how colorblind policies have often failed to address the specific needs and challenges faced by Black students.

Understanding the topology of anti-blackness in U.S. educational spaces requires recognizing its multifaceted nature. It’s not just about individual biases or isolated incidents, but about a systemic structure that shapes the entire educational landscape. This topological perspective highlights the need for comprehensive, systemic approaches to addressing anti-blackness in education, ones that consider the interconnected nature of these challenges and seek to transform the fundamental structure of educational spaces to create truly equitable and affirming environments for Black students and other students deemed as non-white.

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