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Residential Segregation Across Metro St. Louis School Districts: Examining the Intersection of Two Spatial Dimensions

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The present study employs a geospatial analytical approach to studying the evenness-clustering and isolation-exposure dimensions of segregation in the context of the St. Louis, Missouri, metropolitan region. In contrast to global indicators of segregation, this approach focuses on the evenness and isolation dimensions at the local level to visualize how they interact across neighborhoods. While not traditionally thought of as a method for theory testing, geographic information systems (GIS) can contribute to the validation process by displaying how constructs interact when applied in an actual geographic context. We examined separately the segregation dimension of racial evenness-exposure and its intersection with Black isolation and poverty isolation. The study used data from 446 census tracts that represent 65 St. Louis area school districts. When visualizing segregation dimensions through spatial mapping, it becomes apparent that communities that appear diverse may have neighborhoods where individuals or groups remain isolated.

Keywords: *GIS, spatial analysis, residential segregation, diversity, poverty, neighborhood, local context*

Introduction

This *AERA Open* Special Topic aims to better understand the relationship between geography and place and current educational policy developments while also presenting novel research approaches. One well-established and dynamic social problem related to race and poverty involves the trends, patterns, and effects of segregation in education (Tate & Jones, 2017). Education operates as a spatially defined enterprise situated in designated geographies. With boundaries created by laws, customs, and related political engagement, these geographies vary in terms of demographic characteristics, including family resources, student backgrounds, school quality, and academic attainment. The study of contextual factors in education warrants greater use of spatial methodologies to better understand the nature of opportunity (Lubienski & Lee, 2017). Spatial methodologies typically have not been incorporated in the study of educational contextual factors. Tobler's first law of geography informs our understanding of context: "Everything is related to everything else. But near things are more related than distant things" (Miller, 2004, p. 284). Applied to education, this law reflects one of the great challenges to researchers seeking to better understand contextual dynamics of spatial relations and academic attainment in urban regions. Persistent residential segregation necessitates nuanced parsing of geographic space to better understand the geography of opportunity in education (Tate, 2008).

Using a geographic information systems (GIS) approach to study the St. Louis, Missouri, metropolitan area as a geographic region, the present investigation employs geospatial analytical techniques to examine the evenness-clustering (Even-Clus) and isolation-exposure (Iso-Exp) dimensions of segregation (Oka & Wong, 2014; Reardon & O'Sullivan, 2004). It shows how these segregation dimensions and their *interaction* can be given reference locations in geographic space. While traditionally not thought of as a method for theory testing, GIS contributes to the validation process by displaying how constructs interact when applied in an actual geographic context. This study presents an example of how GIS can be used as an analytical approach to visualize a theory that has a strong spatial component that captures variation across a local context.

Previous research (Oka & Wong, 2014; Tate & Hogrebe, 2018) demonstrated how the Even-Clus and Iso-Exp measures of segregation can be mapped, one at a time, as single variables. However, Reardon and O'Sullivan (2004) theorized that two *interacting* dimensions (Even-Clus and Iso-Exp) merit further consideration as indicators of segregation. To understand segregation in terms of the interaction between these dimensions, it is critical to see their interaction in the geographic space of a metropolitan context. Values of the Even-Clus and the Iso-Exp dimensions aggregated across geographical subunits produce global measures for a region as a whole and provide valuable summary information. However, global measures tell only part of the story.

The more important storyline resides in the details of the local neighborhood contexts. Where are the neighborhoods that are diverse and individuals are integrated? Where are the neighborhoods that lack racial evenness and groups are isolated? What type of schools and resources are located in these various Even-Clus and Iso-Exp combinations? What are the practical and policy implications of these different local contexts? Global segregation measures cannot answer these questions (Sudano, Perzynski, Wong, Colabianchi, & Litaker, 2013; Wong, 2003a, 2003b, 2005, 2008). But these "what and where" questions can be answered using GIS to map segregation dimensions in actual geographic space.

For this study, we followed the convention of Oka and Wong (2014) and quantified the segregation dimension of racial Even-Clus using their local spatial diversity index, which incorporates the percentage of Black, White, and other residents in the calculation. In addition, we examined the Iso-Exp dimension separately for Black residents and poor residents and then each in conjunction with the Even-Clus dimension. Mapping the interaction of the racial Even-Clus dimension together with the Black Iso-Exp dimension and again with the poverty Iso-Exp dimension illuminates the "what and where" questions of segregation in the St. Louis metro area.

Race, Segregation, and Academic Attainment

The intractable racial segregation in cities and their surrounding suburbs across the United States makes it important to ask: What associations exist between racial segregation and school-related outcomes? Galster's (2012) synthesis of the literature suggests that the educational opportunities of most Black students are linked intimately to inner-city school districts in large metropolitan regions. Typically racially isolated, he argued that the young persons in these districts experience a cumulative segregation effect that negatively influences the ability of their assigned school districts to support student learning. Local school district revenue disparities, teacher inequality, insufficient cognitive demand of implemented curriculum, and limited outgroup student contact contribute to lower student performance and learning in segregated urban school districts (Galster, 2012; Levin, 2012; Raudenbush, 2012).

Social science evidence indicates that racially diverse schools associate positively with achievement in reading, math, and science as well as secondary school completion, critical thinking, and academic engagement of pupils across racial groups (Berends & Penaloza 2010; Borman et al. 2004; Guryan 2004; Hogrebe & Tate, 2010). For example, Berends and Penaloza's (2010) study of the relationship between racial isolation and mathematics achievement estimated that from 1972 to 2004, increases in school segregation corresponded to significantly slower Black and Latino growth on measures of achievement. School segregation's effects outweighed the positive changes in family background indicators for the non-White demographic groups. Reardon (2016) examined the relationship between 16 distinct measures of segregation and the racial academic achievement (math and English language arts) gaps in Grades 3 through 8 using state accountability test scores for public schools in the United States from 2009 to 2012. A strong association existed between racial segregation and racial achievement gaps. The racial difference in the proportion of students' schoolmates living in poverty represented the mechanism driving the association.

Research focused on addressing racial segregation in schools suggests interventions warrant consideration. Guryan's (2004) examination of data from the 1970 and 1980 censuses indicated that desegregation plans of the 1970s reduced Black high school dropout rates by 2 to 3 percentage points during this period. The dropout rate reductions were more pronounced in school districts that experienced large declines in racial segregation. Gerald Grant's (2009) study of the metropolitan Raleigh, North Carolina, region pointed to better education attainment resulting from school district mergers. The City of Raleigh's school district, which has many areas of concentrated poverty and racial isolation, merged with the more affluent district in Wake County. The study suggested that socioeconomic integration effectively reduced the departure rate of Whites from public education. Racial achievement gaps also narrowed.

Poverty, Segregation, and Academic Attainment

In 2016, 41% of the 72.4 million children under age 18 lived in households categorized as low income (Koball & Jiang, 2018). Educating students in households challenged to meet their basic needs represents one of society's most difficult social problems. Scale and spatial distribution of poverty increase the challenge. Evidence pointing to the negative relationship between poverty and academic outcomes converges (Ruiz, McMahon, & Jason, 2018; Sirin, 2005). Although poverty influences educational outcomes, a focus on how poverty combines with other factors or how it impacts differently across locations remains one of the underdeveloped areas in the literature. Sirin's (2005) meta-analytic study suggests that for Black students, neighborhood and school socioeconomic status (SES), not family SES, may exercise more influence on their academic achievement. Neighborhood factors were related to lower grades. In addition, the potential effect of family SES on Black student performance was context dependent. Family SES effects varied depending on where students lived and the cohort with whom they matriculated in the school. Chetty, Friedman, Hendren, Jones, and Porter (2018) offered additional insight into the relationship between children's neighborhoods and adulthood outcomes. They constructed a publicly accessible atlas of children's outcomes in adulthood covering a majority of the U.S. population. Neighborhoods mattered at a granular level. Poverty rates in children's census tracts were associated with their adult earnings distribution and incarceration rates.

Duncan and Murnane (2011) posited that the efficacy of education depends on spatial context, where increasing concentrations of affluence and poverty and their related effects represent a major challenge for school reformers. The deep-rooted pattern of educational inequality and restricted mobility experienced by disadvantaged groups living in poverty harms children and limits our ability to operate as an informed democracy. Duncan and Murnane argued that economic segregation makes educational inequality less transparent to the prosperous and to society, thus decreasing both a sense of the common good and the level of civic problem solving needed to foster change. They challenge researchers to participate in scholarship that provides greater visibility to and understanding of the relationship between poverty, geography, and academic attainment.

St. Louis Region, Segregation, and Education

Gordon's (2008) geospatial historical analysis described the St. Louis region and the public-private partnerships that fostered residential segregation. It chronicled how federal policy and policymakers, local government officials, and private sector organizations, such as realtors, churches, banks, and neighborhood associations, labored collectively to control Black families' pathways to quality housing. Their actions steered Black families from neighborhoods deemed as more fitting for White families and pointed many of them to segregated public housing and segregated communities. Over the course of the 20th century, the patterns of residential segregation grew in the region. Moreover, residential segregation patterns influenced the racial composition of schools in the region.

While *Brown v. Board of Education* (1954) ended de jure school segregation, de facto segregation remained in St. Louis. In 1972, five Black parents and their minor children filed suit against the St. Louis Board of Education. *Liddell v. Board of Education* (1972) catalyzed a new model for schooling in the St. Louis area, and its recommended resolution—an interdistrict transfer policy—provides a historical framework for this study. In part to address resistance to forced desegregation, suburban school districts agreed to a voluntary desegregation program with St. Louis Public Schools (SLPS). The 1983 settlement created the St. Louis Voluntary Inter-District Desegregation Plan, the largest interdistrict plan in the country with respect to recruitment of students, number of enrollees, and program access (Wells et al., 2009). Under the agreement, Black students from SLPS gained entry by way of transfer to suburban public schools and White suburban students received permission to attend magnet schools in St. Louis City. The SLPS and 16 school districts in adjoining St. Louis County participated in the program. During the apex of implementation, the interdistrict desegregation program enrollment numbered over 14,000 students, nearly twice as many as in Indianapolis, which had the second highest number of enrollees in the country (Voluntary Interdistrict Choice Corporation [VICC], 2013; Wells et al., 2009). Data from standardized tests indicate that the St. Louis interdistrict desegregation program improved Black transfer students' academic achievement outcomes, including graduation rates and college enrollment rates (Freivogel, 2002; Wells et al., 2009). Federal oversight for the program ended in 1999, and the VICC governing board agreed to end new student entry into the program following the 2018–2019 school year. Ultimately, the voluntary interdistrict transfer plan failed to alter the segregated structure of education in the St. Louis region. Moreover, the long-standing racial and educational disparities between SLPS and many suburban school districts in St. Louis County persist. We seek to offer a clearer characterization of segregation in the region.

Segregation Quantified

Segregation has been quantified in a variety of ways. Separate global segregation measures exist, such as the dissimilarity index and the isolation index, that produce one value for segregation across an entire study area (Ellen, O'Regan, Schwartz, & Stiefel, 2012). But from a geospatial perspective, the global segregation indices do not provide information about patterns of segregation that occur in and across local contexts. Segregation measures need to quantify how different population groups are distributed across space (Oka & Wong, 2014, 2015). To visualize how patterns of residential segregation manifest by location, Oka and Wong (2014, 2015) devised two local measures of segregation that correspond to specific places. Developed to quantify the interacting dimensions of spatial segregation identified by Reardon and O'Sullivan (2004), the two local spatial segregation dimensions are spatial evenness versus clustering (Even-Clus) and spatial isolation versus exposure (Iso-Exp) (see Figure 1). The Even-Clus dimension captures how well individuals from different racial groups are evenly distributed within local contexts versus clustered in homogeneous groups. The Iso-Exp dimension refers to the extent that individuals are more likely to encounter members of their own group (isolation) than those of a different group (exposure). The local spatial measures for Even-Clus and Iso-Exp developed by Oka and Wong (2014) demonstrate not only how patterns of spatial segregation exist within districts but also how segregation operates as a spatial process that permeates census tract and district boundaries.

Figure 1 shows the intersection of the Even-Clus and Iso-Exp dimensions that produces four quadrants, which describe the conceptual basis of the different types of segregation proposed by the model. In the following descriptions, the Iso-Exp dimension is used in two separate analyses, with one focused on Black isolation and the other on poverty isolation.

Quadrant 1 (Q1). Different individuals are distributed evenly and exposed to each other.

This is the situation where residential segregation does not exist. Individuals of different racial groups live in integrated neighborhoods. They are distributed evenly within the census tract instead of being clustered in separate neighborhoods (Even-Clus). For the Black Iso-Exp dimension, Black individuals are likely to be exposed to members of other races. For the poverty Iso-Exp dimension, poor families are likely to encounter people with resources exceeding the federal poverty level.

Quadrant 2 (Q2). Some racial clustering, but different individuals have exposure to each other.

Individuals live in racial groupings situated as clusters within the census tract instead of being distributed evenly (Even-Clus). For the Black Iso-Exp dimension, Black individuals are likely to encounter members of other races. For the poverty Iso-Exp dimension, poor families are likely to be exposed to people with resources exceeding the federal poverty level.

Quadrant 3 (Q3). Individuals of different races are distributed evenly, and individuals of the isolated group have less exposure to those who are different.

Individuals of racial groups are distributed evenly within the census tract (Even-Clus). For higher Black isolation in Q3, Black residents are less likely to be exposed to members of other races. A positive characteristic of Q3 is that the few racially different individuals who live there are exposed to the racial majority residents in the census tract. For the poverty Iso-Exp dimension, poor families tend to be isolated from residents who exceed the federal poverty level. Conversely, the fewer residents with greater financial resources are exposed to families in poverty.

Quadrant 4 (Q4). Individuals of different races are clustered, and groups are isolated from each other.

This is the situation of greatest residential segregation. Individuals of different racial groups live in larger, segregated neighborhoods. They are clustered within the census tract instead of being distributed evenly (Even-Clus). For the Black Iso-Exp dimension, Black individuals are isolated and less likely to encounter members of other races. For the poverty Iso-Exp dimension, poor families are less likely to be exposed to people who exceed the federal poverty level.

Data Sources

The data units are St. Louis area census tracts from the 5-year estimates of the 2015 American Community Survey. To show the segregation patterns related to racial Even-Clus and Iso-Exp within and across districts, school district boundaries are visible in conjunction with the census tracts.

Variables

Variables at the census tract level include total population count of people residing in the tract; count of Black population residing in the tract; count of White population residing in the tract; combination count of all other population groups residing in the tract: Asian, American Indian, Hispanic, Pacific Islanders; and count of families with children under 18 years and with income under the federal poverty level (UPL) residing in the tract. The Achievement Variable From the Missouri Assessment Program (2015) was also included and is the percentage of students at a school scoring in the proficient or advanced range on the Missouri fifth-grade language arts test.

Methods

Researchers have used various geospatial approaches and techniques to investigate the segregation dimensions of Even-Clus and Iso-Exp (Oka & Wong, 2014; Reardon & O'Sullivan, 2004; Tate & Hogrebe, 2018). To study these segregation dimensions from a spatial perspective, researchers operationalize them by mapping each at the local level of census tracts. Census tracts and school district boundaries are "modifiable areal units" in that their shape and size are based on demographic and political factors. The unit is modifiable in that it can be changed based on different interpretations. If data analysis or political decisions are dependent on arbitrary boundaries, then results and decisions can be changed by simply modifying them. Gerrymandering that reshapes voting districts illustrates a classic example of the consequences of modifying areal units. To avoid the instability of arbitrary boundaries and better understand the continuous patterns and processes that operate across neighborhoods and communities in metro regions, we used composite population counts for the census tracts (Oka & Wong, 2014, 2015). Use of composite population counts mitigates the effects of manmade boundaries that define arbitrary units of different sizes (i.e., census tracts and school district boundaries). By taking into account characteristics in adjacent units, composite population counts allow spatial processes to operate unimpeded across artificial boundaries.

A study by Frankenberg, Siegel-Hawley, and Diem (2017) provides a practical example of the modifiable areal issue, which demonstrated the profound effect arbitrary changes in school and district boundaries had on segregation within and between districts. Even though the rate of residential mobility did not change, their study showed the negative effects on segregation that modifying boundaries had on the racial composition in Memphis–Shelby County, Tennessee, districts and schools. Changing manmade boundaries has very real consequences and should be the focus of

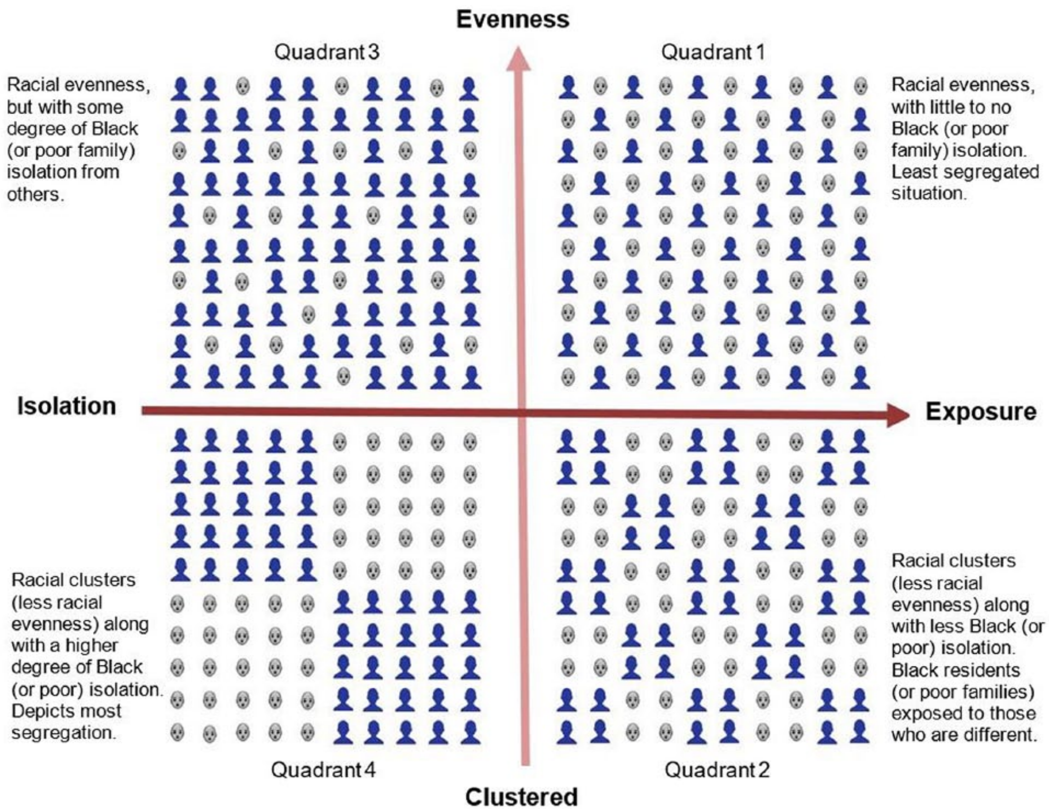

FIGURE 1. *Interaction between two local spatial segregation dimensions: evenness (evenness vs. clustering) and isolation (isolation vs. exposure) adapted from Oka and Wong (2014). The racial evenness dimension captures how evenly individuals from different racial groups are distributed within local contexts versus clustered in homogeneous groups. Isolation refers to the extent that individuals are more likely to encounter members of their own group than those of a different group (exposure).*

continual evaluation and policy discussion. However, from a spatial perspective, it is also important to understand the underlying processes that continue to operate despite changes in manmade boundaries. Composite counts allow for a better assessment of the spatial processes at work.

The study calculated composite population counts for each census tract by simply summing the number of the target group members (e.g., residents) in each conterminous census tract and then adding this sum to the number of target members in the reference tract (Oka & Wong, 2014, 2015; Tate & Hogrebe, 2018). For example, if the reference census tract has 6,000 residents and its conterminous tracts have 4,000, 5,000, 7,000, and 8,000 residents, respectively, then the composite count for the reference tract would be 30,000 (4,000 + 5,000 + 6,000 + 7,000 + 8,000) (see Figure 2).

The data consist of 446 census tracts from the 5-year estimates of the 2015 American Community Survey. These tracts approximate the St. Louis, Missouri, metropolitan region and represent 65 Missouri school districts. This study defined the Even-Clus dimension by the percentage of Black, White, and other residents in the composite counts for each of the 446 census tracts. Even-Clus was dominated by the percentage of Black and White residents in that the average combined percentage of Black and White residents in the census tracts was 94.5%.

We analyzed two Iso-Exp dimensions separately in conjunction with the Even-Clus dimension. The first Iso-Exp dimension was the percentage of Black residents, and the second was the number of families with children under 18 years and with income UPL. The intersection of each Iso-Exp dimension with the Even-Clus dimension shows the location of Black isolation and poverty isolation in combination with the extent of and variation in racial evenness across the metro area.

The study visualized variability and relationships in the segregation dimensions of Even-Clus and Iso-Exp across St. Louis, Missouri, area districts geospatially using ArcMap 10.4 (Environmental Systems Research Institute, 2010). We mapped census tract data because they represent smaller geographic areas than school districts. These smaller units make it possible to discern patterns of segregation within district boundaries.

To quantify the dimensions, Oka and Wong (2014) used the local spatial entropy-based diversity index for the Even-Clus dimension and the local spatial isolation index to measure Iso-Exp. The researchers developed both

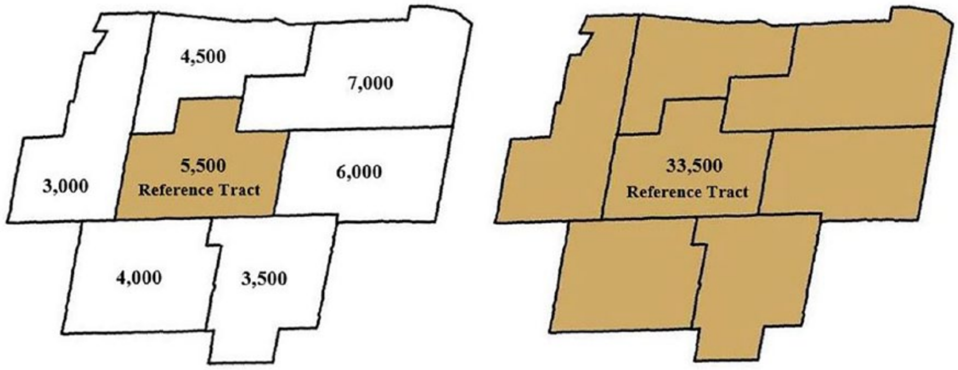

FIGURE 2. *The conceptual process of obtaining a composite count for each census tract (adapted from Oka & Wong, 2015). Values in conterminous census tracts are summed and added to the reference tract for the composite count.*

indices based on formulas using composite population counts (Wong, 2008), as described in the following. We then converted each index to z scores for use in subsequent analyses.

$$\text{Local spatial diversity index for evenness} = -\sum_{k}^{n}\left(\frac{cp_{ik}}{ct_i}\right)\ln\left(\frac{cp_{ik}}{ct_i}\right),$$

where cp_{ik} is the composite population count for mutually exclusive group k in the census tract and ct_i is the composite population count for the total population in the census tract.

$$\text{Local Black isolation index} = 1-\left(\frac{ct_i - cb_i}{T-B}\right),$$

where cb_i is the composite population count for Black residents in the census tract, ct_i is the composite population count for the total population in the census tract, and B and T are the counts of Black and total population for the entire study area.

$$\text{Local poverty isolation index} = 1-\left(\frac{ct_i - cp_i}{T-P}\right),$$

where cp_i is the composite count for poor families UPL with children less than 18 years old in the census tract, ct_i is the composite count of the total families with children less than 18 years old in the census tract, and P and T are the counts of (P) poor families UPL with children less than 18 years old and (T) total families with children less than 18 years old for the entire study area.

We derived the intersection of the Even-Clus and the Iso-Exp dimensions using values above and below the means of the evenness and isolation indices to create four quadrants matching those defined in Figure 1.

For racial evenness-clustering and Black isolation:

Q1 = evenness values above the mean and Black isolation values below the mean;
Q2 = evenness values below the mean and Black isolation values below the mean;
Q3 = evenness values above the mean and Black isolation above its mean;
Q4 = evenness values below the mean and Black isolation above its mean.

For racial evenness-clustering and poverty isolation:

Q1 = evenness values above the mean and poverty isolation values below the mean;
Q2 = evenness values below the mean and poverty isolation values below the mean;
Q3 = evenness values above the mean and poverty isolation above its mean;
Q4 = evenness values below the mean and poverty isolation above its mean.

We mapped the values of racial evenness and Black isolation located in each of these four quadrants simultaneously to show how these dimensions intersect across the actual geographic space of the St. Louis metro area. GIS provides the ability to visualize concurrently the four quadrants of two-dimensional segregation while also depicting the spatial distribution of a subgroup (i.e., percentage Black residents or families UPL) at the census tract level. An integrated picture of how segregation looks across neighborhoods and school districts emerges when these five key components are viewed together. Adding a sixth component to the map that represents the location of neighborhood schools creates an even further detailed analysis, with the point size corresponding to the level of fifth-grade language arts proficiency. The measure of proficiency, fifth-grade language arts, captures an important stage of reading comprehension ability

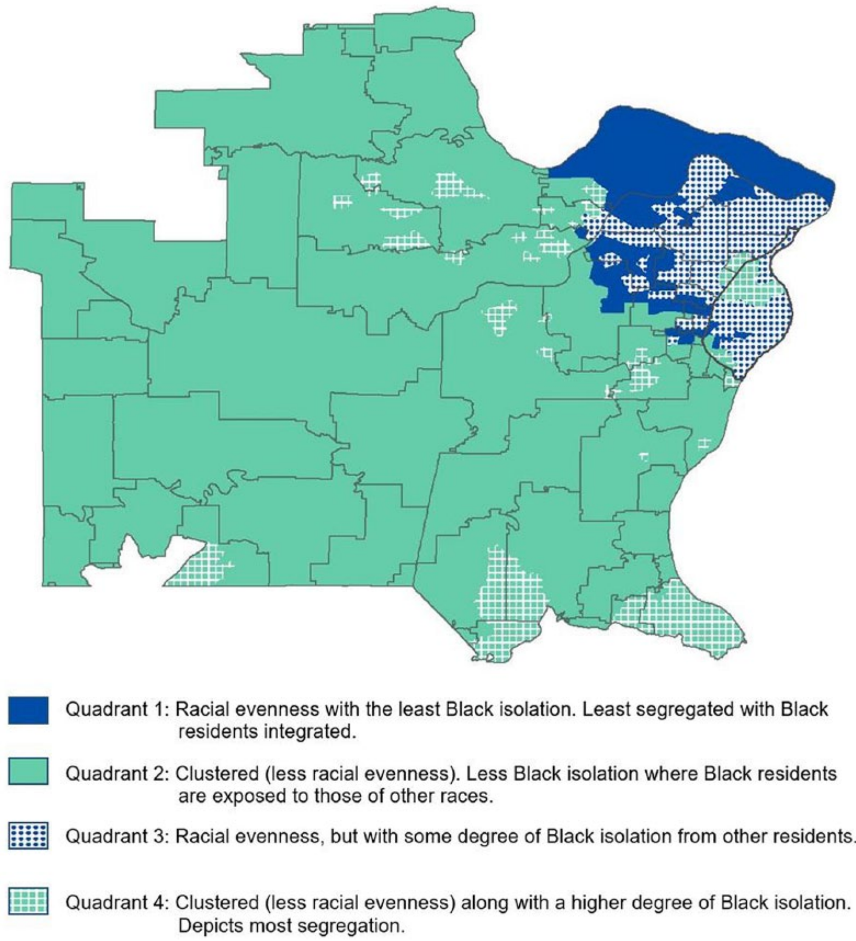

FIGURE 3. *Racial evenness and Black isolation intersection for St. Louis Metro school districts. (Q1) Solid blue areas represent least segregated tracts, where there is greater racial evenness and little Black isolation. (Q2) Solid green areas display tracts with less racial evenness but also less Black isolation, meaning that Black residents are more likely to be exposed to individuals of other racial groups. (Q3) Small blue dot tracts represent areas of racial evenness but with some degree of Black isolation from other individuals. (Q4) Large green square tracts are those with racial clusters (less racial evenness) that also have a higher degree of Black isolation. Depicts most segregation.*

(Oakhill & Cain, 2012). The study offers an exemplar to demonstrate how additional grades and subjects can be analyzed in a geospatial context.

Results

Racial Evenness-Clustering and Black Isolation

Figure 3 displays the results of dividing the racial evenness and Black isolation scores into four quadrants and shows the intersection of these two dimensions with actual data. Solid blue areas (Q1) represent the least segregated tracts, with greater racial evenness and less individual Black isolation. Solid green areas (Q2) display tracts with less racial evenness (some degree of clustering) but more exposure, meaning that Black individuals are less isolated. Small blue dot areas (Q3) represent tracts with greater racial evenness but where Black individuals can be isolated, with fewer opportunities to interact with members of other racial groups. Large green square tracts (Q4) represent the most segregated tracts with more racial clustering together with Black individuals who are isolated.

To gain a better understanding of Black isolation in areas with racial evenness, we mapped the percentage of Black residents in each census tract in conjunction with Q3 represented by the small blue dots in Figure 4. The color gradient behind the dots shows where higher and lower concentrations of Black residents exist. It is apparent that the degree of isolation for Black residents is not uniform across Q3 despite being represented as an area with racial evenness. The easternmost blue dot tracts have a greater percentage of Black residents who are more isolated in that they have a higher probability of encountering members of their own group. In addition, the eastern green squares (Q4) in St. Louis City show an extensive group clustering area with

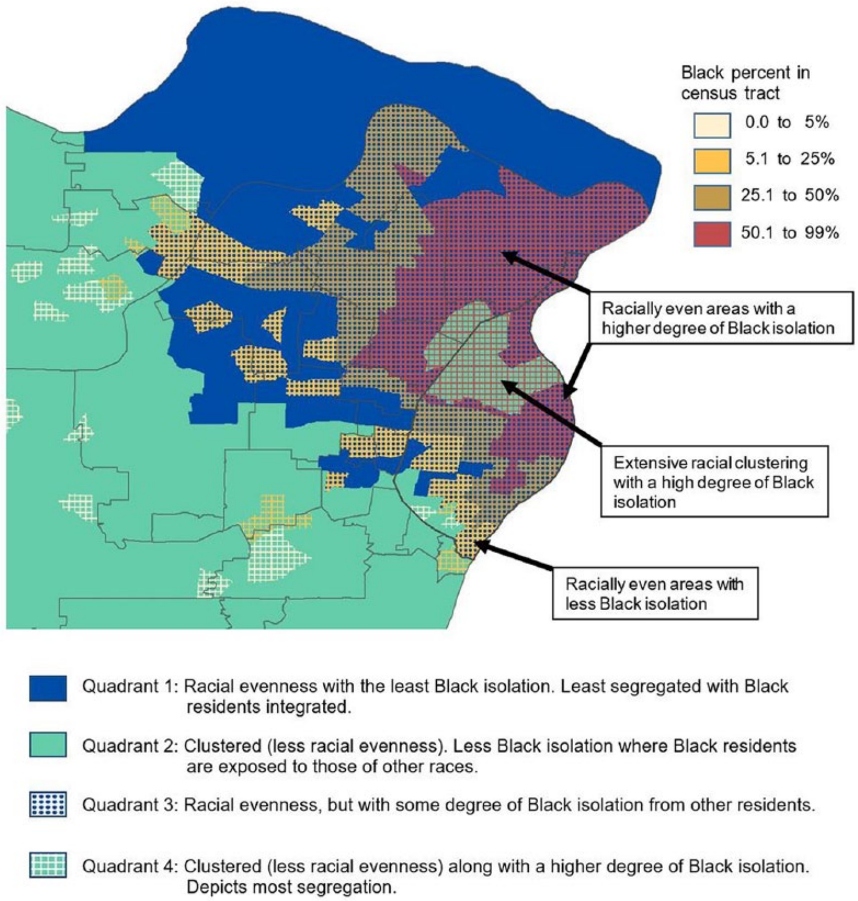

FIGURE 4. *Racial evenness and Black isolation intersection for St. Louis Metro school districts as represented in Figure 3, with the addition of percentage Black residents in census tracts that shows Black isolation variation within Q3 and Q4.*

less racial evenness and a high degree of Black isolation. This combination indicates a highly segregated area of the city that lacks racial evenness and where Black residents are isolated.

The spatial relationship between school location, achievement, racial evenness, and Black isolation can be seen in Figure 5. Using the percentage of students scoring in the proficient or advanced range on the Missouri fifth-grade language arts test, school academic performance is situated by location within the racial evenness and Black isolation patterns. These dimensions highlight the residential segregation aspect of the local context in which the schools operate. Figure 5 shows that the achievement of schools near racially even neighborhoods with less Black isolation (Q1) tends to have higher percentages of proficient/advanced fifth-grade language arts students. In contrast, most schools in both the racially clustered (Q4) and racially even (Q3) northern areas of St. Louis City with high Black isolation have fewer proficient students. There are exceptions, and higher performing schools in these areas are easy to spot in Figure 5. There is one charter school (green diamond) in the area that is racially clustered and with high Black isolation (Q4) where 72% of fifth-grade students are proficient/advanced in language arts. Also, four other schools in this area have between 33% and 66% of their students scoring proficient/advanced. The map shouts the obvious question, “How are students in these schools located in a highly segregated area performing so much better than their peers?” This is the type of value-added information that is readily visible when multiple variables are presented simultaneously in a geospatial format.

Racial Evenness-Clustering and Poverty Isolation

The four quadrants displayed in Figure 6 show the intersection of racial evenness and poverty isolation dimensions. Solid blue areas (Q1) represent the least segregated tracts, with greater racial evenness and less poverty isolation. Solid green areas (Q2) display tracts with less racial evenness and lower poverty isolation, meaning that poor families are more exposed to those who are not UPL. Small blue dot areas (Q3) represent tracts with greater racial evenness but where poor families can be isolated. Large green squares (Q4) represent the most segregated tracts where there is less racial evenness and poor families are isolated. It is apparent that a

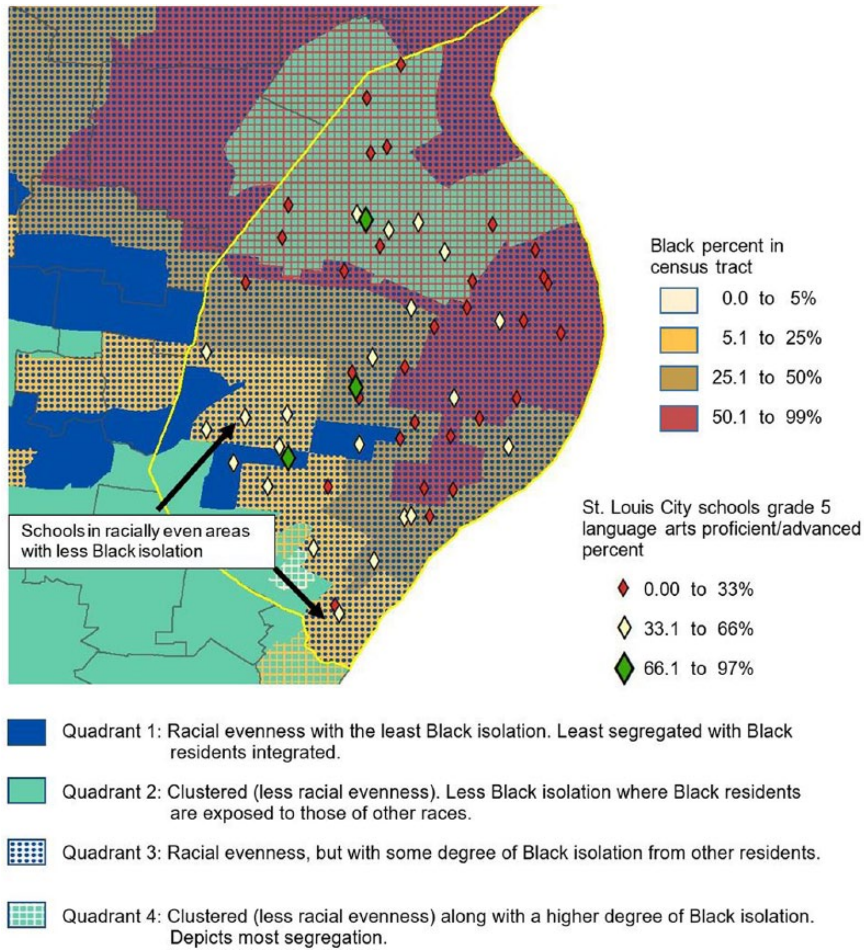

FIGURE 5. *Same as Figure 4, but with St. Louis City school location and percentage of fifth-grade students who scored proficient or advanced on the language arts Missouri achievement test. Shows that the achievement of schools in (Q1) neighborhoods that exhibit racial evenness with little Black isolation tend to have higher percentages of students scoring proficient/advanced in fifth-grade language arts. In contrast, most schools in both (Q3) the racially even and (Q4) clustered northern areas of St. Louis City with high Black isolation have fewer proficient students. There are exceptions, and higher performing schools in these areas are easy to spot in Figure 5.*

number of pockets exist across the area that have racial clusters and contain poor isolated families (Q4).

To visualize the relationship between poverty isolation in areas with more racial evenness, we mapped the percentage of families UPL in each census tract in conjunction with Q3, represented by the small blue dots in Figure 7. The color gradient behind the dots shows higher and lower concentrations of poor families UPL with children under 18 years old. The pattern reveals that the distribution of isolated poor families is not uniform across Q3, which is depicted as an area with racial evenness. The census tracts in the easternmost racially even tracts (blue dots) have a greater percentage of poor families and therefore are more isolated in that they have a higher probability of encountering other poor families. In addition, the northern green squares in St. Louis City (Q4) show an extensive racially clustered area with a high degree of isolated poverty. This combination delineates a highly segregated area of the city in terms of racial clustering and poverty.

Against this backdrop of neighborhoods that vary in racial evenness and poverty, we can see the spatial relationship between school location, achievement, racial evenness, and poverty isolation. Figure 7 shows that the achievement of schools in racially even neighborhoods with less poverty isolation tends to have higher percentages of proficient/advanced fifth-grade language arts students. In contrast, most schools have fewer proficient students when located in either racially clustered or even areas of St. Louis City that are coupled with high poverty.

Comparing Black Isolation and Poverty Isolation

Despite areas of overlap in the intersections of racial evenness with Black isolation and poverty isolation, the

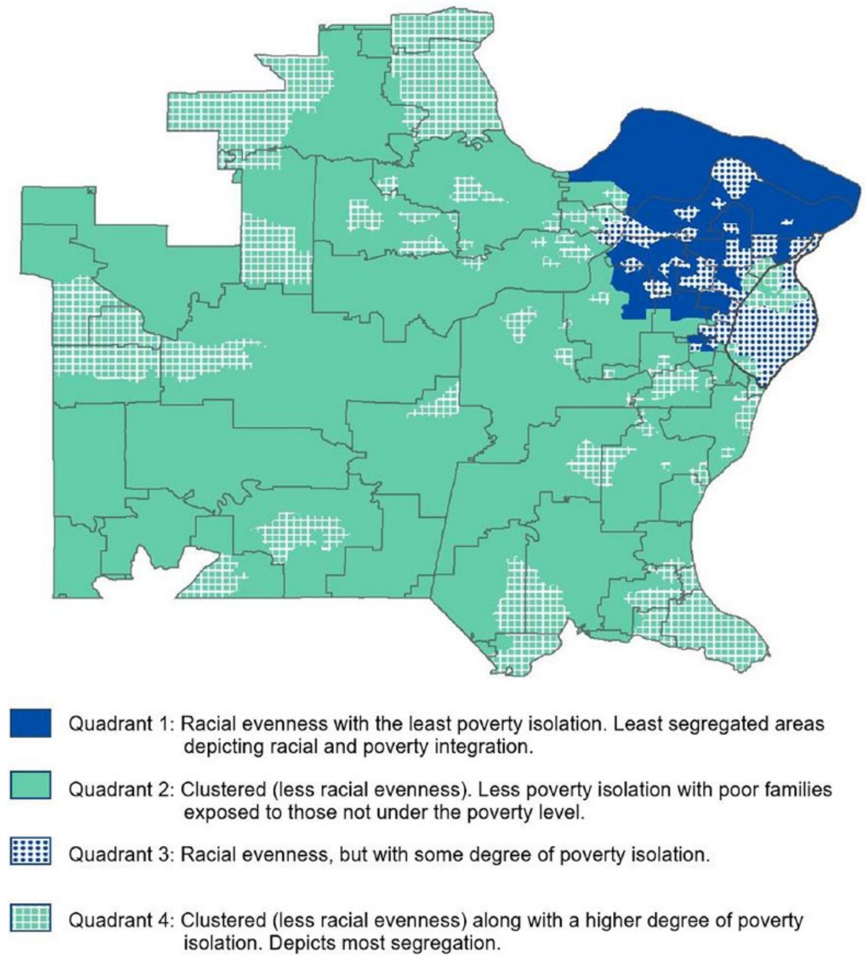

FIGURE 6. *Racial evenness and poverty isolation intersection for St. Louis Metro school districts. (Q1) Solid blue areas represent least segregated tracts where there is greater racial evenness and little family poverty isolation. (Q2) Solid green areas display tracts with less racial evenness but also less poverty isolation, meaning that poor families are more likely to be exposed to families who exceed the federal poverty level. (Q3) Small blue dot tracts represent areas of racial evenness but where poor families are mostly isolated from those not in poverty. (Q4) Large green square tracts are those with racial clustering that also have a higher degree of poverty isolation where poor families are isolated from those exceeding the poverty level. Depicts most segregation.*

patterns of segregation depicted in the four quadrants differ for these two types of isolation. Local contexts vary in racial diversity, Black isolation, and poverty isolation, which combine to produce unique neighborhood characteristics. Visualizing these differences in geographic space with GIS helps us to understand the variation between the two dimensions of segregation. For example, Figure 6 shows more areas of racial evenness with less poverty isolation (blue in Q1) compared to racial evenness and Black isolation in Figure 3 (blue in Q1). Also, Figure 6 shows many segregated areas with greater racial clustering and higher poverty isolation (more green squares in Q4). In contrast, Figure 3, Q4 depicts fewer segregated areas with racial clustering (fewer green squares) and high Black isolation. Similar comparisons can be made when examining Figure 5 versus Figure 7.

Discussion

The present study identifies spatial segregation at the local level within school districts and also shows where segregation operates as a continuous process across district boundaries. The study offers two types of implications: future analytical approaches in segregation research and local social policy. Accordingly, we divide the discussion of the results into two sections. We conclude with a brief discussion of thoughts on future spatial approaches.

Analytical Implications

From a methodological standpoint, a significant contribution of this study is that it emphasizes the importance of using a local spatial approach to quantifying the Even-Clus and the Iso-Exp dimensions of segregation. The study presents

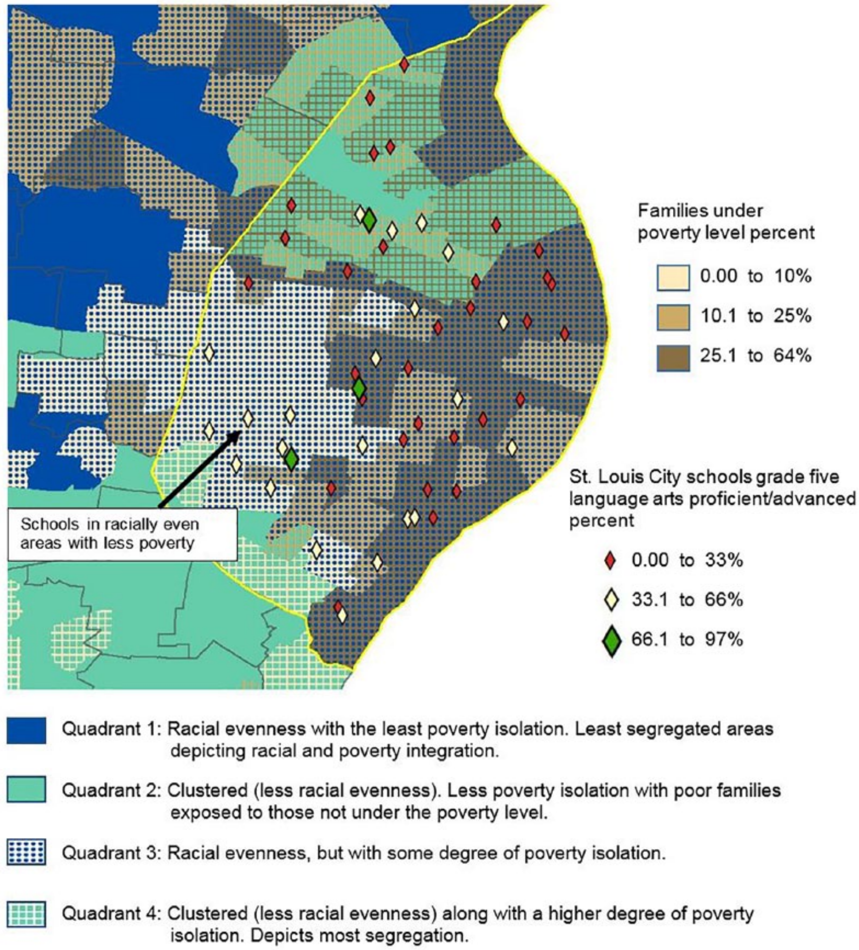

FIGURE 7. *Shows that the achievement of schools in (Q3, lightest areas) neighborhoods with racial evenness and less poverty isolation tend to have higher percentages of proficient/advanced fifth-grade language arts students. In contrast, most schools in both the (Q3, darker areas) racially even and (Q4, darkest areas) racially clustered tracts of St. Louis City with high poverty have fewer proficient students, although there are some exceptions with (large green and tan diamonds) schools performing better in these segregated areas.*

a geospatial approach that demonstrates how to display the interaction between the Even-Clus and the Iso-Exp dimensions when describing segregation in neighborhoods and communities. This approach recognizes the importance of place (Dreier, Mollenkopf, & Swanstrom, 2014; Tate & Hogrebe, 2018) to understand the local context in which social processes and neighborhood effects operate (Sampson, 2012).

An important result from our analytical approach is the ability to illustrate that in regions that appear diverse and where individuals and groups are potentially exposed to each other, there may also be areas or neighborhoods where individuals or groups are isolated. Pockets of isolation and segregation can exist in areas that appear diverse. The present results support the conceptual framework of two dimensions (Even-Clus and Iso-Exp) in the study of segregation and demonstrate how they interact. Not surprisingly, the areas of concentrated segregation also include those with the greatest poverty and economic disadvantage.

Policy Implications

Academic performance as measured by the language assessment varied across the region. Consistent with the literature, high poverty and racially segregated regions experienced relatively lower academic performance. Exceptions existed, and these schools warrant further study. Does the St. Louis case provide lessons for policymakers in other communities? The variation in performance aligns with other studies of segregation and academic achievement that suggest opportunity to learn differs based on underlying conditions such as the school quality, neighborhood factors, and the economic status of families (e.g., Reardon, Kalogrides, & Shores, 2018). With respect to school quality, the St. Louis metropolitan desegregation order offers insight into a possible regional reform. The St. Louis interdistrict desegregation transfer program generated many positive outcomes. An education and economic case can be made for reestablishing a robust VICC-like model in St. Louis (Tate & Jones, 2017). Efforts to make school transfer more accessible to students in low-performing districts have been met with political resistance. The pushback is consistent with the Raleigh, North Carolina, metropolitan transfer plan (Grant, 2009). Despite the challenge, the evidence and history of success suggest this strategy warrants continued consideration in St. Louis and other similarly situated regions.

Limitations and Future Possibilities

While this article focuses on visualizing the dimensions of segregation in geographic space at the level of local context, the next step involves integrating segregation analysis with other key community factors. This necessitates an understanding of the evenness-clustering and isolation-exposure dimensions of segregation so that students affected adversely by separation from critical resources can be connected to appropriate educational and community support systems. The type and degree of segregation must be delineated because of the significant impact these factors have on the equal opportunity and quality of education for isolated student groups. In addition to the multifaceted descriptive analyses presented here, other applications of GIS include (but are not limited to) examining variable relationships across space with techniques such as geographically weighted regression that account for spatial autocorrelation (e.g., Hogrebe & Tate, 2015a, 2015b), identifying statistically significant variable clustering (e.g., Tate & Hogrebe, 2018), and network analysis for finding optimal routes and accessibility to schools (e.g., Harrison, Burgoine, Corder, van Sluijs, & Jones, 2014). Understanding how these factors interact in the local context helps form a "critical spatial perspective" (Morrison & Garlick, 2017; Soja, 2010) that can lead to the development of informed courses of action.

Finally, it is important to note that the quantitative GIS approach to studying segregation does not in and of itself present a complete picture of all the issues. Integrating a qualitative approach with quantitative GIS analytics can bring about a much greater understanding of the processes operating in local contexts as well as providing resources for community action and understanding (Hogrebe & Tate, 2012; Tate & Hogrebe, 2011). We agree with Yoon and Lubienski (2017), who advocate the use of mixed-methods GIS to enrich policy research in education. They maintain that a mixed-methods GIS approach that incorporates macro- and microlevel analyses leads to greater understanding of educational issues.

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