REPRODUCING INEQUALITY? A GEOSPATIAL ANALYSIS OF SCHOOL ATTENDANCE ZONES IN SOUTHERN NEW MEXICO

BY

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To Indigo

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ABSTRACT

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It is well documented that school segregation has an adverse effect on children's educational outcomes. In recent years an emerging body of research points to an increase in socioeconomic and racial segregation in public schools across the United States. Neighborhood composition proves to be one of the most important forces behind school segregation since most students attend schools they are geographically assigned to. This study explores the relationship between the socioeconomic and racial composition of school attendance zones and academic performance in a predominantly Hispanic, metropolitan area in southern New Mexico. This quantitative analysis integrates aspatial and geospatial data sets from the US Census Bureau, the National Center for Educational Statistics, and New Mexico Public Education Department.

Results found segregation between schools and school attendance zones. Findings also revealed an inverse relationship between the socioeconomic composition of the schools (and school attendance zones) and academic performance. However, in the school attendance zones, percentage minority had a larger effect on academic performance than poverty rates. In addition, there were significant differences between mean poverty and minority rates along the shared school attendance boundaries of low and high performing schools. High poverty and high minority neighborhoods were assigned to low performing schools and low poverty, low minority neighborhoods were assigned to high performing schools. Results indicate school attendance boundaries serve as socioeconomic barriers to educational equality and may leave low-income, minority students anchored to underperforming schools.

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1.1 Statement of the Problem

On May 17, 1954, the United States Supreme Court ruled that “separate but equal” public schools for blacks and whites were unconstitutional in the landmark case of Brown v. Board of Education of Topeka (Conference 2016). This case was instrumental in paving the way for widespread desegregation efforts in public schools across the United States. Federal and state desegregation programs, especially prevalent in the South, were achieved by redistricting, shifting school attendance boundaries to be more inclusive, and bussing students from African American neighborhoods to predominantly white schools. However, since the 1990’s when the Supreme Court began relaxing desegregation orders, there has been a growing trend towards socioeconomic and racial/ethnic segregation in public schools (Orfield and Lee 2004; Owens and Reardon 2016).

According to an analysis by the U.S. Government Accountability Office (GAO) between the school years of 2000-01 to 2013-14 the percentage of K-12 public schools with high percentages of poor and African American or Hispanic students nearly doubled (Nowicki 2016). Consequently, African American and Hispanic students are more likely to attend a high-poverty school than white-non-Hispanics. In fact, the National Center for Educational Statistics estimated that in school year 2014–15, nearly half of Hispanic and Black public-school students attended high-poverty schools compared to only 8 percent of white non-Hispanic students (NCES 2017). High concentrations of minorities in high-poverty schools is problematic considering research shows low-income students who attend schools with low poverty rates are nearly 70 percent more likely to attend college than if they attend a high-poverty school (Nowicki 2016). Across the country, minorities and low-income students are isolated in public schools where their peers share the same demographic.

Since the 1970's, the number of underrepresented minorities has risen dramatically and the income inequality gap is larger now than it has ever been (Orfield and Lee 2004; Reardon and Bischoff 2011). Consequently, racial, ethnic, and economic segregation in public schools is reaching new heights. In fact, the GAO study found the percentage of schools that were racially or socioeconomically "isolated[1]" grew from 9 percent to 16 percent between the 2000-2001 and 2013-2014 school years (Nowicki 2016). Segregated schools are especially prevalent in states that never fell under historic desegregation orders, as well as, those that have seen large increases in minority populations such as Hispanics/ Latinos in the Western states (Orfield and Lee 2004). This is an alarming trend since the effects of school segregation on disadvantaged populations are profound.

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[1] "Isolated" schools are defined as schools in which 75 percent or more students are of the same race, ethnicity, or socioeconomic demographic.

It is well documented that school segregation has a debilitating effect on the educational outcomes of children (Coleman 1966; Rumberger & Palardy 2005; Palardy 2008; Schwartz 2010; Reardon 2011; Lareau 2014). Segregation typically leaves minority and poor children in inferior schools, located in less desirable physical locations with less experienced teachers, large class sizes, less resources, less challenging curriculum, and more student behavioral problems (Logan, Minca and Adar 2012). The combination of these factors creates a poor environment for any child to succeed. Consequently, school segregation is associated with lower academic proficiency in elementary school and lower high school graduation rates for students that are poor and/or minority (Johnson 2014; Quillan 2014). Research also indicates that student outcomes are much higher when minority and low-income students attend schools that are integrated and where the average socioeconomic status is higher (Tefera, et al. 2011). Although much is known about the negative effects of segregation, the intersection between the origins of segregation and academic performance in schools, especially pertaining to Hispanic/Latino populations, is a less explored topic.

Until recently, school segregation research largely focused on the occurrences or effects of segregation by examining the racial and socioeconomic composition of the school student body, unrelated to the residential school attendance zone[2] assigned to the school. This omission was a great oversight since school attendance zones, the

[2] Also referred to as a catchment zone or catchment area.

geographic area from which students are assigned to a public school, determine the socioeconomic composition of its corresponding school. Recognizing the importance of school attendance zones is essential to understanding how segregation occurs and the ways in which segregation could be avoided. However, more recent research acknowledges that attendance zones serve as the main contributor to school segregation and are one of the only tools left for integration following years of court supported dismantling of school integration programs (Bischoff 2008; Saporito & Sahoni 2009; Diem, et al. 2015; Richards 2015; Saporito & Van Riper 2016).

Recognition of the relationship between school segregation and school attendance zones contributed to the proposed Stronger Together School Diversity Act of 2016 that intended to authorize $120 million dollars supporting the integration efforts of local school districts (Education 2016). These integration efforts include revising school boundaries and expanding bussing services to increase the socioeconomic and racial diversity in schools. This bill came on the heels of President Obama’s FY 2017 Stronger Together budget proposal that emphasized the desperate need to reverse the tide of segregation that is happening in schools across America.

1.2 Contributions of the Study

Considering the large impact school attendance zones have on students, relatively few studies geographically examine the socioeconomic composition of school attendance zones which ultimately determine the public-school demographics of schools that the majority of American children attend. Although sociologists have begun investigating the role of school attendance zones and neighborhoods as related to segregated schools, they have strongly emphasized the need for more research in this area (Talen 2001; Bischoff 2008; Owens 2016; Owens, Reardon, & Jencks 2016; Saporito & Van Riper 2016).

Their research, aimed at understanding the spatial relationships between school attendance zones and school segregation, has emphasized aspects such as gerrymandering, the redistricting process, or the impact of alternative school choice on public school segregation. Nearly all these studies are confined to samples of large, densely populated, urban school districts. According to Logan (2012), nonmetropolitan schools have been largely ignored in segregation literature although they are a significant presence in the overall educational system. As a result, our understanding of how the spatial composition of attendance zones mirrors segregation in schools and how this relates to academic performance in smaller urban areas is lacking. Furthermore, research attempting to spatially predict whether students from low income, high minority neighborhoods will be assigned to low performing schools is relatively unknown.

Understanding spatial segregation on a finer spatial scale would be very informative for smaller, geographically isolated school districts that are different from densely populated metropolitan school districts. For example, smaller school districts may have fewer obstacles integrating schools since there are fewer (or no) competing school districts in which students could enroll. In this light, smaller school districts may have greater flexibility to experiment with models that could help reduce between-school segregation.

In addition, there is a lack of research exploring this topic as related to economic segregation or white-Latino/Hispanic segregation which often follows different patterns than black-white segregation. Such an understanding is important because the Hispanic/Latino population is the fastest growing minority group in the United States and their experience of school segregation often includes not only segregation by race/ethnicity and economics, but linguistic segregation as well (Orfield and Lee 2004, 2006). Studies examining economic segregation between schools is also essential since the disparity in outcomes is driven by socioeconomic inequalities that occur when schools are comprised of students of different races (Reardon and Owens 2014). Furthermore, evidence shows Latino- white (non-Latino) residential segregation is determined by economics and class, rather than Latino ethnicity (Wahl, et al. 2006).

This research seeks to fill that gap, as well as extend aspatial studies examining school student body composition with geographic analytics such as spatial autocorrelation and geographically weighted regression to predict school assignment.

This study investigates the spatial relationship between the racial/ethnic and socioeconomic composition of school catchment zones as related to their accompanying school, as well as, compares existing school attendance zones to alternate models. Consequently, the results reveal the degree of segregation between schools as related to school performance in a predominantly Hispanic, metropolitan area in southern New Mexico.

This study integrates data sets from the Census Bureau, school performance and demographic data from the New Mexico Public Education Department, and maps of school attendance boundaries from Las Cruces Public School District. Through this integration, I explore the possibility that low performing schools serve as anchors for minority students in high poverty neighborhoods. Through geospatial analysis techniques, I examine the relationship between the socioeconomic and racial/ethnic composition of school attendance zones with each other, the schools they serve, and the overall district. I also analyze the relationship between the socioeconomic and racial composition of schools as they relate to academic performance. In addition, the socioeconomic composition of neighborhoods, along the perimeter of adjacent elementary school attendance zones is examined to predict a neighborhood’s chance of attending a high or low performing school based on neighborhood demographics. Lastly, the socioeconomic composition of existing school attendance zones is compared with an alternate school zone model.

1.3 Research Questions:

This study sought to answer the following questions:

- Does the racial/ethnic composition of each school attendance zone reflect the racial/ethnic composition of the school assigned to that zone?
- To what degree are elementary schools in Las Cruces Public School District and their attendance zones segregated?
- Is academic performance a function of the socioeconomic composition of the school and the school attendance zone?
- Does the socioeconomic composition of a neighborhood predict its inclusion into a high or low performing school?
- How do the current socioeconomic compositions of school attendance zones compare with alternate models?

1.4 Theory

This research is motivated by critical, post-structuralist, and Marxist theoretical ideas. The social, cultural, and spatial reproduction theories of Henri Lefebvre and Pierre Bourdieu, as well as David Harvey's theory of social injustice, support the idea that school segregation, which occurs as a result school attendance zone segregation, is a product of the inequities that proliferate in a capitalist society, including social and class reproduction.

Henri Lefebvre argues in *The Production of Space* that space is socially constructed based on the hierarchical structure of a society (Lefebvre 1974). This hierarchical structure affects how space is physically represented and perceived, especially in the urban environment. According to Lefebvre, the social production of space is controlled by the hegemonic class to assert its power and reproduce the class structure, especially within the framework of capitalism. Lefebvre's conceptualizations of space are embodied in the reproduction of social inequity from one geographic space to another, as seen in geographic school assignment. The reproduction of residential segregation into the educational system is made possible by the school assignment process. In addition, segregation and inequalities in public-school systems are often overlooked.

Public policy often obstructs proven ways of remedying segregation like bussing, redrawing boundaries, and redistricting. In fact, public opinion polls indicate an increasing opposition to race-based school desegregation policies such as busing (Reardon and Owens 2014) . A complex web of factors contributes to the proliferation of segregation in public schools and much of this is driven by those with the most agency and power.

Parents, especially those who are economically disadvantaged, typically do not have flexibility to choose the school their child will attend, nor are they able to move to more affluent residential locations to access better schools. By comparison, educated and affluent parents have long understood the relationship between geography and schools, for example, choosing and selling real estate based on school zoning (Schwartz 2010; Cucchiara 2013; Lareau 2014). Affluent parents often choose neighborhoods that mirror their own socioeconomic status and demographics. It is likely parents want the school their child attends to reflect the culture and class of the neighborhoods they have selected. In addition, research shows white parents will avoid placing their children in high minority schools or leave as the percentage of minorities increase (Chubb and Moe 1997; Saporito and Sohoni 2007; Lareau 2014).

Lefebvre addresses urban patterns of segregation by arguing against any type of balanced urban system. Instead, towns are defined by fragmentation and the reproduction of social relations that are often being threatened (Lefebvre 1973). The same could be said of school attendance zones and school district zones. These zones determine the schools that students will attend, and unless consciously drawn to integrate students of various socioeconomic backgrounds, will likely reproduce existing residential segregation.

David Harvey attributes inequality in urban environments to the inherent structure of capitalist society. Harvey says urban struggle is grounded in the idea that "the accumulation of wealth, on the part of a capitalist class, depends entirely on the accumulation of debt" (Harvey 2012). For Harvey, imbalance is a natural component of capitalism and extends beyond economics and into the uneven development of urban environments. Spatial practices, where space is experienced, is the arena in which change can be made or inequalities can persist (Cresswell 2013). For Harvey, those with the power to produce space are incredibly influential as they hold the instrument which allows them to reproduce and enhance their own power (Creswell: 131). According to Harvey, "Any project to transform society must, therefore, grasp the complex nettle of the transformation of spatial practices" (Harvey 1989, 261). If school attendance boundaries are drawn to replicate existing residential inequalities in which low-income residents are clustered together and high-income residents in another, we can only expect the same imbalance reproduced in our schools. Likewise, if we want to change the forces that enable segregation, we must also consider our "spatial practices."

French sociologist Pierre Bourdieu acknowledged the interplay between structure and agency more so than the more Marxist-aligned social theorists. For Bourdieu, space was constantly being reproduced by all actors involved rather than a top-down structure imposed upon individuals. He was first to elaborate on the relationship between class power struggles and social capital which takes place within social fields (Siissiainen 2000). Social fields are social settings where people enact their social positions (Bourdieu 1993). "As fields, all spaces within society are contested; and actors' positions within them have to be fought for continually" (2000, 17). This imbalance and struggle for power is played out across the educational landscape in a myriad of ways, most of which are tied to economics, class, race, and space. In relation to desegregation policy, the social spaces physically represented in school attendance zones and school district boundaries, are the hotly contested "fields" that should be considered, or segregation will persist. School attendance zones also reproduce residential segregation and class structure into schools.

The intent of this study is to look at the physical origins of segregation that are replicated in schools. I argue racial and class stratification are reproduced from neighborhoods into schools, whether by replicating residential segregation or engineering school catchment or school district zones to avoid diversity. If neighborhoods show significant patterns of inequality then neighborhood schools will replicate these same inequalities, unless school districts make intentional efforts to draw boundaries that encourage socioeconomic diversity.

2. LITERATURE REVIEW

2.1 Introduction

Research concerning segregation often focus on issues regarding the opportunity and achievement gap between minority and/or economically disadvantaged students compared to non-minority/wealthier students (Coleman 1966;

Jencks and Phillips 1998; Palardy 2008). More recent attention to the spatial segregation of school attendance boundaries has focused on the spatial planning of districts and school accessibility, proving or disproving gerrymandering, school district fragmentation in dense metropolitan areas, or issues surrounding school choice patterns, such as, presence of charter and private schools encouraging “white flight” (Saporito and Sohoni 2007, 2009; Abel 2012; Johnson 2014).

Residential patterns determining the socioeconomic composition of neighborhoods is a driving force contributing to school segregation. Past studies often note that higher income families consider schools when making residential choices (Frankenberg 2009; Lareau 2014; Owens 2016). Consequently, pockets of residential areas are often socioeconomically homogenous. Although alternative school choices may be available to parents with the means to access them, researchers have found that even when parents are given a choice, school proximity is instrumental when deciding which school their child will attend (Hastings, Kane and Staiger 2005). According to the latest school choice data from the U.S. Department of Education (2014), in 2012 approximately 85 percent of all students enrolled in grades 1-12 attended the school to which they were geographically assigned.

This literature review analyzes research concerning segregation and the achievement gap, general considerations for spatially planning school districts, attendance zone and district gerrymandering, and the relationship between school choice options and segregation.

2.2 The Socioeconomic and Racial Composition of Schools: The Opportunity and Achievement Gaps

Although progress has been made in school integration since the Civil Rights Act of 1964, current research indicates racial segregation is widespread throughout the nation and is on the rise (Orfield and Lee 2006; Abel 2012; Owens, Reardon and Jencks 2016). The latest research also reveals that although racially segregated schools are significant and prevalent, an equally distressing phenomenon is the substantial increase is socioeconomic (SES) segregation. Of course, economics intersects race and ethnicity, and it is well documented that minority students are much more likely than white students to attend high poverty schools (Orfield and Lee 2006). However, researchers have discovered that even controlling for race, ethnicity, and student background characteristics, students in low SES schools achieve far less academically than students attending schools with a higher socioeconomic composition (Kennedy 1986, Palardy 2008; Perry and McConney 2010). This is a result of the opportunity gap students of lower socioeconomic status face. The opportunity gap refers to unequal access to the resources needed to be successful in school. Without access to experienced, high-quality teachers, advanced curricula, and a climate of high expectations, disadvantaged students concentrated in high-poverty, resource low schools are bound to have lower educational outcomes.

2.2.1 African American Segregation

After the passage of the Civil Rights Act of 1964, the U.S. Office of Education commissioned sociologist James S. Coleman (1966) to investigate issues “concerning the lack of availability of equal educational opportunity by reason of race, color, religion, or national origin in public educational institutions at all levels...” (1966: iii). Coleman and his team used data from over 600,000 students and teachers across the country. The report reiterated what they already suspected; most children attend schools in which their own race is the majority, and African Americans have lower achievement and are more impacted by the quality of their school than white children. Quality of school was measured as curriculum offered, school facilities, and the school composition, including the academic, personal and social backgrounds of teachers and students. Furthermore, as students progressed through school, the academic achievement gap widened between white and minority children, indicating schools were largely ineffective in reducing the achievement gap.

2.2.2 Socioeconomic Status and Segregation

Perhaps the largest take away from Coleman’s study was the discovery that academic achievement was less related to the quality of the school (in terms of facilities, curriculum and textbooks) and more tied to the social composition of the school. According to Coleman (1966), "the social [class] composition of the student body is more highly related to achievement, independent of the student's own social background, than is any school factor" (1966: 325).

Ultimately Coleman and his team suggested minority children would have better outcomes if they attended racially integrated schools, exposing them to people of different backgrounds, experiences, and different educational expectations. The research was significant, documenting for the first time immense racial and ethnic segregation in public schools and acknowledging there is a difference between equality and equity. The findings propelled the US Department of Education to implement large scale desegregation programs throughout the country (Kiviat 2000).

Likewise, more recent studies have confirmed Coleman's findings. In a study examining the effects of school-based economic integration in Montgomery County, Maryland, students from low-income public housing units were assigned to low-poverty schools and academically tracked alongside peers who were academic equals and also came from public housing (Schwartz 2010). The students attending low poverty schools significantly outperformed their peers who attended moderate to high poverty schools, even though the school district invested more money and resources in the low poverty schools during the study period. Furthermore, school-based economic integration had twice as large of an effect on academic performance for low-income children than neighborhood-based economic integration.

2.2.3 Hispanic/Latino and Segregation

Although black-white segregation in the South was not completely eradicated and is still present today; it is less prevalent compared to other regions in the United States. According to Orfield and Lee (2006), in 2003-2004, the states with the highest levels of black-white segregation in the nation were New York, Illinois, California, and Michigan. The relative success of the South is most often credited to strictly enforced desegregation policies which took the form of intentional redistricting, school attendance boundary manipulation, and bussing black students to white majority schools (Orfield and Lee 2006; Abel 2012; Richards 2014).

Unfortunately, these desegregation programs did not significantly affect the Hispanic/Latino populations. The Supreme Court did not address desegregation of Hispanic/Latino majority schools until the Keyes v. Denver School District case (1973). This case allowed African American and Latino students to be placed in the same category when defining and measuring segregation, acknowledging both groups suffer the same inequalities compared to white students. However, an unfortunate and lasting result of this case, is that plaintiffs need to prove de jure segregation not just de facto segregation[3]. This has immensely affected desegregation efforts and significantly contributes to the current increase in segregation not only in Denver, but

[3] De jure segregation is defined as segregation imposed by law, as opposed to de facto segregation; segregation because of societal differences or discrimination, but it is not officially written into law.

across the United States (Haas n.d.). Regardless of this case, the desegregation of Hispanic/Latino students was weakly enforced. The primary issue embraced by Hispanic/Latino rights advocates was bilingual education, not integration (Orfield and Lee 2006). Subsequently, with little attention concerning the segregation of Hispanic and Latino students, Hispanic/Latino segregation has rapidly grown in public schools, eclipsing the rate of black-white segregation especially in Northeastern, Southern, and Western states (2006: 10).

Orfield and Lee (2006) point out that the segregation of Hispanic and Latino students is especially significant since students are not only segregated by ethnicity but often linguistically. If Latino students are isolated in schools with fewer fluent, native speakers of academic English, this diminishes the likelihood they will excel in high school and beyond. Furthermore, the intersectionality between race/ethnicity and poverty cannot be ignored. Orfield and Lee (2007) reveal that the average Latino student attends a school in which 60 percent of the population is poor compared to the average white non-Latino students who attends schools in which only one third of students are poor. In addition, studies reveal high minority, high poverty schools have disproportionally fewer math, science, and college preparatory courses, not to mention higher suspension and expulsion rates (Nowicki 2016).

Orfield and Lee's research concluded that students in high poverty schools (as measured by students on free and reduced-price lunch) do not have the same educational opportunities as students in wealthier schools, possibly for the same reasons cited in Coleman's report. Numerous studies since the Coleman Report strongly indicate that integrating minority students and low-income students into schools with a greater percentage of students from higher socioeconomic families significantly improves the academic outcomes for disadvantaged students (Jencks 1971; Chubb and Moe 1997; Schellenberg 1999; Rumberger and Palardy 2005; Schwartz 2010).

A myriad of factors contributes to this; notably that schools with a more balanced socioeconomic makeup tend to have more access to challenging coursework such as advanced placement classes, higher qualified teachers, and higher expectations for students (Palardy 2008). Scholars have also pointed out that although resources may be equally distributed, schools with higher percentages of low income students typically require more resources since these schools often have more academic and behavioral problems (Jencks and Phillips 1998).

Students from higher income families also tend to have parents with more education and consequently high educational expectations for their children, the school, and its teachers. These parents often have more experience navigating education bureaucracies, have more social, cultural, and financial capital, hence are more likely to lobby for better resources and programs for their schools. It is likely schools with a larger percentage of students with social, cultural, and financial capital lead to a school "habitus[4]" that rewards academic achievement and the expectation that students will continue to university. This type of school environment positively affects all students, not just those from privileged backgrounds.

This inevitably leads us to the complicated question as to why are we experiencing an increase in school segregation. Numerous factors are at play, not just your geography, but the politics within your geography; for example, presence of charter schools, private schools, school vouchers, and school choice.

2.3 Gerrymandering School Attendance Boundaries for Integration or Segregation

Scholars have explored how school attendance boundaries are intentionally engineered to create more racially balanced schools or are potentially used as a tool of segregation (Leigh 1997; Saporito and Sohoni 2006, 2007, 2008, 2009; Abel 2012; Siegel-Hawley 2013; Richards 2014, 2015; Saporito and Van Riper 2016). The results were mixed with some scholars emphasizing school attendance boundaries typically serve to segregate students while others emphasize how school boundary manipulation is used to integrate students, as evidenced in the South. Various

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[4] Habitus is a sociological theory popularized by Pierre Bourdieu that explains a person's actions or habits, which are performed through everyday actions. These actions are the result of deeply ingrained cultural and socioeconomic norms that shape a person's behavior.

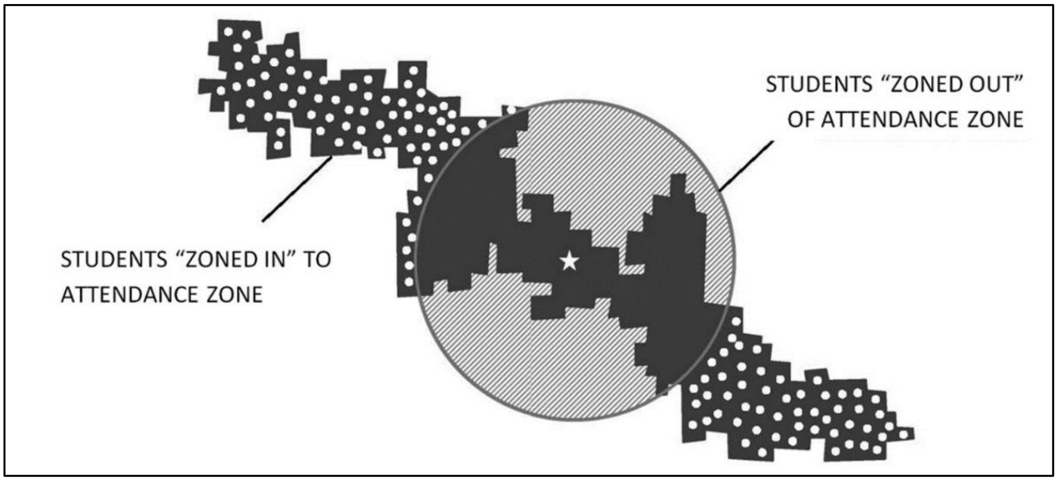
geospatial methods are employed to explore school attendance zones, including those drawing on political gerrymandering research and other methods exploring the shapes of zones and their compactness.

2.3.1 Are School Attendance Zones Intentionally Manipulated to Segregate?

Researchers have employed geospatial analysis to explore the possibility that boundaries are intentionally manipulated to include certain students while excluding others (Richards 2014, 2015; Saporito and Van Riper 2016). Richards (2014) drew on the voter exchange framework in electoral zone gerrymandering research (Angel and Parent 2011) to investigate her hypothesis that school boundaries are highly gerrymandered to inhibit racial diversity.

Through a “student exchange framework” Richards (2014) focused on how schools choose students through irregular boundaries that include some students while excluding others. Figure 1 illustrates the student exchange process as a result of gerrymandering. The white star indicates the location of the school and the long, black figure the existing gerrymandered attendance zone. The circle indicates the natural, compact zone without the presence of gerrymandering. The hatched lighter gray area in the circle are students “zoned out” by gerrymandering while the dotted black areas are students “zoned in.”

Figure 1: Student Exchange Process



Note. Reprinted from "The gerrymandering of school attendance zones and the segregation of public schools: a geospatial analysis," by Richards, M., 2014, American Educational Research Journal, *51(6)*, p. 1126

Richards acknowledges gerrymandering attendance boundaries into irregular patterns, particularly in Southern states under desegregation orders, has successfully adopted an "affirmative role," racially diversifying neighborhood schools (2014: 1125). However, she emphasizes that as desegregation laws have relaxed, schools are becoming more segregated. In her latest article, Richards claims attendance zones are highly gerrymandered, especially those in cities experiencing rapid racial change and areas with high populations of white, affluent families (Richards 2015).

One of the most interesting contributions by Richards (2014) was the construction of Voronoi polygons (also known as Thiessen polygons) around schools to compare the hypothetical racial composition of school zones centered around the point locations of schools with the existing, irregularly shaped school attendance zones.

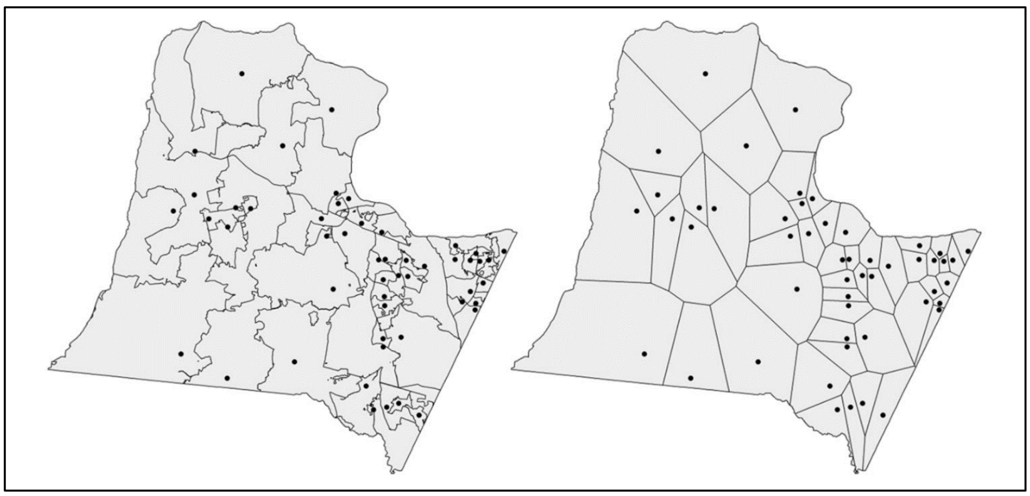
Thiessen polygons, which draw on computational geometry, were named after Alfred Thiessen (1911) who used them to measure rainfall surrounding rain gauges (Arlinghaus 1991). Since rain gauges represent point locations, Thiessen and his companion Alter, divided the area into mutually exclusive polygons so that any location within each polygon was closer to the central point location (rain gauge) inside the polygon than any other rain gauge outside of the polygon. Nowadays, Thiessen polygons are relatively easy to construct using ArcGIS and often serve to create buffer zones and determine areas of influence around sample points distributed across a plane, such as a map. Each polygon-buffer serves as a "base map" in which data (such as Census data) can be interpolated around a central, sample point without zones overlapping as they would be using circular buffer zones. The data within each polygon-buffer zone is averaged and a value assigned to each zone.

Richards used this method to measure the racial/ethnic composition within hypothetical school attendance zones centered around a school (the sample point), to the racial/ethnic composition of existing zones. She argued the hypothetical Voronoi polygons were "natural" neighborhood attendance zones and that the existing boundaries were irregularly shaped and therefore "gerrymandered" school attendance zones. By comparing the Voronoi models to the existing zones, Richards sought to determine whether the gerrymandered zones resulted in more or less segregation than zones without gerrymandering. 15,290 attendance zones in 663 school districts were used in the sample (Richards 2014). In one case illustration; Loudoun County Public

School District, a suburb outside of Washington, D.C., demonstrated her finding that districts released from desegregation orders and that have experienced high rates of racial/ethnic and economic change, are especially segregated.

Figure 2 displays existing school attendance zones in Loudoun on the left and the Voronoi zones on the right. The black dots indicate the school location.

Figure 2**:** Actual Zones vs. Hypothetical "Voronoi" Zones



Note. Reprinted from "The gerrymandering of school attendance zones and the segregation of public schools: a geospatial analysis," by Richards, M., 2014, American Educational Research Journal, *51(6)*, p. 1128

Her analysis determined that actual school attendance zones in Loudoun County were .08 - .27 standard deviations more racially/ethnically segregated than their Voronoi zones (1149: 2014).

Another case illustration in the same study revealed another obvious example of students zoned out of an attendance boundary. Figure 3 displays zones in a school district in the suburban South. The dark gray area in 3a shows an actual attendance zone overlaid with a Voronoi polygon (the hatched gray area). 3b-d show census blocks with the percentage of students that are Hispanic, Black, and White, respectively, within the attendance zone. Especially striking is the rectangular "hole" in 3B where a census block with a high percentage of Hispanic students are "zoned out."

Figure 3: Zones Gerrymandered to Reduce Diversity

Note. Reprinted from “The gerrymandering of school attendance zones and the segregation of public schools: a geospatial analysis,” by Richards, M., 2014, American Educational Research Journal, *51(6),* p. 1139

Although the exclusion of this block is not captured in the Voronoi polygon, it does suggest the presence of gerrymandering. Illustrations 3b-3d, according to Richards, show higher percentages of white non-Hispanic zoned into the existing zones and minorities zoned out, especially in the northeast and southeast (1140: 2014).

Saporito and Van Riper's study (2016) contradicted those of Richards and the scholars criticized Richards for failing to test for irregularity in the shape of the zones. Although Saporito and Van Riper's assessment included more geospatial tools measuring the irregularity of the shapes, Voronoi polygons naturally account for irregularity because they are completely convex and lack "nooks and crannies" (Richards 2014, 1128). Furthermore, the feature that makes Voronoi polygons a sufficient model for measuring gerrymandering is that it defines an area of influence around its sample point, in this case the physical location of the school, so that any location of students inside the polygon is closer to that point than any other sample point (school). This is important since proximity to a neighborhood school is a strong factor among parents when deciding which school their child will attend.

In a later study, Richards, measured the shapes of school attendance boundaries with additional indices to identify indentation, compactness, and dispersion, supporting her claim that gerrymandering is often used as a tool to segregate (Richards 2015). Richards found zones were highly gerrymandered especially in suburban and rural towns compared to major metropolitan areas. This is likely due to the impact of rapid influx of minorities to the suburbs and rural towns (Orfield and Luce 2013; Siegel-Hawley 2013; Diem, et al. 2015).

Saporito and Van Riper's assessment (2016) determined the irregularity of shapes using three measures; concavity (CV), convex hull (CH) and Polsby Popper (PP). Concavity, as developed by Chambers and Miller (2010), is determined by measuring the convexity of shapes. A perfectly convex shape is one where unique pairs of data (in this case children's residential locations within an attendance zone) can be connected in a straight line without passing through the boundary of an attendance zone (Saporito and Van Riper 2016, 71). If this is achieved, the zone is considered completely compact. Examples of convex shapes are circles, triangles or rectangles. A concave shape, on the other hand, is a zone shaped like a crescent or star where pairs of children would cross attendance boundaries. Concave shapes have a high number of lines passing through a boundary (72: 2016).

A convex hull is the smallest polygon (convex shape) that completely encloses a set of locus points (ESRI 2016). In this study, locus points are children surrounding an attendance zone. Saporito and Van Riper describe this as a rubber band stretched around a concave shape such as an irregularly shaped attendance zone (72: 2016). The researchers created convex hulls for attendance zones in the study and the school-aged children counted within the convex hulls (not the attendance zones). A convex hull with a value that equals zero is considered compact while a value of one indicates an irregular zone.

The last measure of compactness used, was the Polsby-Popper, also known as a Perimeter Measure. This measures the ratio of the area of a zone (or district) to the area of a circle with the same perimeter as the zone or district (Lublin 2014). This measure is sensitive to boundaries that have many indentations that will deliver a low score (near zero, indicating irregularity) compared to those with smooth boundaries (close to one, indicating compactness). Saporito and Van Riper explain the importance of including Polsby-Popper because it is able to measure elongated shapes, like rectangles, as irregular, whereas the CV and CH measures cannot (2016: 72).

The scholars found most attendances zones were compact, square-like shapes that were racially homogenous. This suggested that patterns of residential segregation drove segregation, not gerrymandering. In fact, their findings claimed most irregular attendance boundaries (mostly found in the South) were actually more diverse than the more compact ones, a likely result of desegregation policies.

The relatively “square” attendance zones found in Saporito and Van Riper’s study appear similar to some of the zones in my proposed study. However, schools are not located in the mean center of a school attendance boundary. We should consider the idea that while still accounting for ease of transportation, population density, and other practical matters, the boundaries could be drawn differently to change the composition of the schools, while still maintaining a reasonable geographic distance from the school.

The limitations of many of these geospatial studies is the limited exploration of economic segregation. Many scholars agree economic segregation is eclipsing racial as the most prevalent form of segregation in neighborhoods and the schools assigned to them (Perry and McConney 2010; Schwartz 2010; Reardon and Bischoff 2011; Reardon 2011; Reardon and Owens 2014; Quillian 2014; Roberto 2016; Owens 2016; Owens and Reardon 2016). Another limitation is that examining large samples throughout the United States fails to address irregularity due to natural or anthropogenic boundaries which a small area study, like this study, investigates.

2.3.2 The Politics of Exclusion: Redistricting Schools

Changes in the racial/ethnic and socioeconomic composition of cities across America has led to the controversial practice of creating new, racially and economically homogenous school districts. Scholars have investigated the relationship between education inequality and school and neighborhood segregation primarily through redistricting case studies and find that school district boundary lines are the main culprit of segregation and educational inequality (Leigh 1997; Bischoff 2008; Siegel-Hawley 2010; Abel 2012; Siegel-Hawley 2013; Diem, et al. 2015).

2.3.3 Racially Changing Cities, Suburbs, and School Districts

The rapidly changing racial and ethnic composition of cities across the United States has led to patterns in unequal access to public services such as schools (Hastings, Kane and Staiger 2005; Lareau 2014; Chisesi 2015). School district "fragmentation" results when school districts, typically in densely populated areas decide to split and create new school districts. Many scholars who study "between district" segregation have shown this can result in patterns of segregation far more severe than seen between schools because of population density.

Bischoff (2008) compares diversity across districts using residential sorting theory and the Theil index of segregation. Her findings emphasized that fragmentation increases multiracial segregation between districts and is often a consequence of the fragmentation of political jurisdictions. Political jurisdictions are integral in providing services for neighborhoods and public education is of course one of those services. This is especially problematic for school district integration since the Milliken v. Bradley (1974) decision ruled interdistrict bussing unconstitutional. According to Bischoff, this left within district transfers the only option and thus made it impossible to prevent "white flight" since suburban districts were independent of inner cities (207: 2008). This ruling essentially protected large metropolitan areas from desegregation laws and led to the creation of "white districts" and "black districts".

Frankenberg (2009) studies this topic as well with a case study examining how the creation of new school districts in Jefferson County, Alabama legally maintained racial segregation in the Birmingham area. While all these studies are informative they do not typically address the issue with spatial tools, instead they compare demographic data between districts. Bischoff recognizes this weakness because it assumes that households located in different data clusters are less similar to each other than those within the same data cluster, ignoring the possibility neighborhoods along the same boundary may be similar (2008:195). In theory, neighborhoods sharing a common boundary line should, according to Tobler's Law (1970), have more in common with each other than locations farther away. If they do not, we should investigate why.

2.4 School Choice Proximity, School Composition, and the Impact on Neighborhood Schools

Several studies have examined the impact of school market competition on school districts and school catchment areas (Saporito and Sohoni 2006, 2007, 2009). Research demonstrates alternative school options, such as a prevalence of charter, magnet, and private schools in a city, often leads to more segregated neighborhood schools. This challenges the popular idea in many education circles that the more school choice options there are in a school district, the more diverse schools will become, giving poor and minority students a chance to "escape" high poverty schools

(Chubb and Moe 1997). Unfortunately, economics, work schedules, and transportation issues often prevent this from being a viable option for many families.

2.4.1 School Choice Patterns and "White Flight"

Saporito and Sohoni (2007; 2009) were at the forefront of employing geospatial analysis methods to examine the relationship between neighborhoods, school attendance zones, and school segregation. In the earlier study, using population weighted interpolation methods and the exposure index to measure segregation between poor and non-poor students; they observed the degree of segregation between schools across a district was highly influenced by the composition of school catchment areas. Saporito and Sahoni also focused on the role of school choice options, such as the prevalence of charter and private schools, race and poverty often predicted the amount of poor in a school.

Districts with high percentages of minority/poor students led to more segregated neighborhood schools, more so than the actual school attendance zones the students were coming from. As demonstrated in Table 1, in twenty-one observed school districts, the average poor child lives in a neighborhood where 37 percent of the children are poor, yet they attend a school in which 60 percent of the children are poor, suggesting white, affluent children were not attending their neighborhood schools (Saporito and Sohoni 2007).

Table 1: Segregation between Poor and Non-Poor Students in School Attendance Boundaries and Neighborhood Schools.

	Percent Poor			Exposure			Decomposition of School-Level		Dissimilarity		
	District	Schools		Boundaries	Schools		Residential	School	Boundaries	Schools	
School District	a	b	b-a	c	d	d-c	e	f	g	h	h-g
New York City	39.5	72.6	33.0	49.3	79.1	29.8	4.6	35.0	34.9	41.7	6.8
Los Angeles Unified	42.9	77.2	34.3	52.2	83.5	31.3	4.5	36.1	33.9	46.8	12.9
City of Chicago	37.6	65.4	27.8	48.7	70.0	21.3	5.5	26.9	35.9	29.0	-6.9
Dade County	32.9	62.2	30.5	42.3	72.3	30.0	5.8	33.6	34.6	45.8	11.2
Broward County	22.0	35.6	13.6	32.3	54.8	22.5	10.5	22.3	36.3	49.6	13.3
Philadelphia City	40.0	69.8	29.8	50.9	77.0	26.1	8.3	28.7	36.6	44.3	7.7
Houston I.S.D.	40.7	71.3	30.6	49.1	78.3	29.2	5.5	32.1	31.0	40.0	9.1
Clark County	21.0	28.5	7.8	32.6	44.0	11.4	9.7	13.3	40.7	43.8	3.1
Detroit City	45.3	70.0	24.7	49.5	72.5	23.0	2.5	24.7	23.1	25.3	2.2
Dallas I.S.D.	38.9	72.0	33.6	45.3	75.1	29.8	3.6	32.6	26.7	27.7	1.1
Hillsborough County	23.7	44.8	21.2	32.4	55.6	23.2	5.8	26.1	33.0	39.4	6.4
Fairfax County	7.6	13.9	6.3	15.3	27.9	12.6	6.1	14.2	43.0	44.6	1.5
Palm Beach County	20.0	42.3	22.3	30.9	60.6	28.7	9.6	31.0	37.0	49.6	12.7
San Diego City	33.7	54.6	21.3	51.8	68.2	16.4	8.8	25.7	49.8	49.5	-0.3
Orange County	24.3	36.5	12.3	32.7	45.4	12.7	5.1	16.0	30.9	32.7	1.8
Prince George County	13.3	38.6	25.2	20.3	46.7	26.4	3.5	29.9	35.0	32.1	-2.9
Duval County	22.7	43.7	21.0	34.0	55.1	21.1	8.5	23.9	35.6	38.9	3.3
Montgomery County	9.0	20.0	11.3	14.8	32.3	17.5	3.9	19.4	32.8	39.7	6.9
Pinellas County	18.1	35.7	17.6	24.8	42.2	17.4	2.5	21.6	27.7	28.6	0.9
Baltimore City	39.2	71.0	32.2	49.6	74.5	24.9	5.5	29.8	36.4	30.2	-6.2
Baltimore County	10.6	23.2	12.6	17.3	36.0	18.7	5.3	20.1	33.3	42.0	8.8
Mean across districts	27.8	50.0	22.3	37.0	59.6	23.6	6.0	25.9	34.7	39.1	4.5

Note. Adapted from "Mapping educational inequality: concentrations of poverty among poor and minority students in public schools," by Saporito, S.; Sohoni, D., 2007, Social Forces, *85(3)*, p. 1243

In a later study, Saporito and Sahoni (2009) use GIS to explore segregation and focus on racial data. Table 2 illustrates the dissimilarity indices for school catchment zones and the schools they served. A dissimilarity index measures the evenness in which students of the same racial/ethnic group are distributed evenly across a district. A dissimilarity index of zero indicates perfect integration while an index of one indicates maximum segregation (93: 2007). The research revealed differences in the number of students in schools compared to their corresponding attendance zones and suggested that “free market” education options (private, charter, and magnet schools) were pulling whiter, affluent children out of neighborhood schools.

Table 2**:** Measure of Segregation in Public and Private Schools

Dissimilarity Indices between White and Black Children across Schools and Their Corresponding Attendance Boundaries *(Elementary Schools)*

School District	Neighborhood Attendance Boundaries (A)	Neighborhood Schools (B)	(B - A)	Private, Charter, and Magnet Schools C	(C-A)	All Schools (D)	(D - A)
New York City	0.67	0.71	0.03	0.79	0.12	0.75	0.08
Los Angeles Unified	0.64	0.71	0.07	0.67	0.03	0.74	0.1
City of Chicago	0.68	0.71	0.03	0.72	0.04	0.74	0.06
Dade County	0.36	0.51	0.16	0.59	0.23	0.55	0.19
Broward County	0.41	0.48	0.06	0.45	0.04	0.48	0.07
Philadelphia City	0.72	0.73	0.01	0.82	0.1	0.78	0.07
Houston I.S.D.	0.59	0.66	0.06	0.67	0.07	0.71	11
Clark County	0.4	0.41	0.01	0.38	-0.02	0.41	0.01
Detroit City	0.61	0.73	0.12	0.78	0.17	0.75	0.14
Dallas I.S.D.	0.6	0.61	0.01	0.58	-0.02	0.72	0.12
Hillsborough County	0.32	0.4	0.08	0.56	0.24	0.42	0.1
Fairfax County	0.32	0.36	0.04	0.32	0	0.37	0.05
Palm Beach County	0.44	0.5	0.06	0.43	-0.01	0.53	0.09
San Diego City	0.58	0.51	-0.07	0.54	-0.03	0.54	-0.04
Orange County	0.38	0.42	0.04	0.49	0.11	0.46	0.07
Prince Georges County	0.52	0.57	0.05	0.58	0.06	0.62	0.1
Duval County	0.42	0.4	-0.03	0.59	0.17	0.44	0.01
Montgomery County	0.36	0.39	0.02	0.52	0.16	0.43	0.07
Pinellas County	0.29	0.28	-0.02	0.44	0.15	0.33	0.04
Milwaukee	0.59	0.51	-0.07	0.65	0.07	0.6	0.01
Baltimore City	0.69	0.78	0.09	0.75	0.06	0.8	0.11
Baltimore County	0.53	0.57	0.04	0.58	0.04	0.59	0.06
Column averages	0.51	0.54	0.04	0.59	0.08	0.58	0.07

Note. Adapted from “Mapping school segregation: using GIS to explore racial segregation between schools and their corresponding attendance areas,” by Saporito, S.; Sohoni, D., 2009, American Journal of Education, *115*, p. 590

Although these studies are very telling, there is limited use of spatial tools analyzing the data beyond mapping and aggregating data. Another limitation of this research is the implication that the results can be generalized to all school districts in the country, when in fact alternative school options are not prevalent outside of major cities, and 85 percent of children actually attend the school they are assigned to (NCES 2014). As acknowledged by many scholars, smaller districts should also be analyzed which this research sought to address.

2.5 The Spatial Planning of Attendance Zones and School Access

Although there is not a substantial amount of research describing the process of school attendance zone planning or accessibility, a few papers suggest several factors to keep in mind when designing school zones (Maxfield 1972; Hyland 1989; Tefera, et al. 2011). Several factors include; transportation, future population growth, eliminating overcrowding, and achieving a racial balance. Hyland (1989) gives a very brief outline describing the importance of considering these factors while Maxfield (1972) maps five possible plans an administrator could use to distribute students. Most examples use linear programming and minimum distance calculations. However, considering the date of Maxfield's article (1972) and the advancement of geospatial software, the planning school catchment zones could employ tools that are more intricate.

2.5.1 Planning Attendance Zones

Some state public education departments provide guidelines but the task is typically left to individual school districts. On a national level, any issues pertaining to catchment zone planning emerged from legal cases such as Brown vs. the Board of Education (1954) and the Civil Rights Act of 1964, which made racial segregation illegal and led to federally mandated desegregation orders in several Southern states. A more recent case, Parents Involved in Community Schools v. Seattle School District No. 1 (2007), made it illegal to use race as a factor when admitting students to school, even though the intention was to racially diversify schools. This significant case left catchment zone planning as the only option for diversifying schools.

2.5.2 School Access

School access is often viewed in terms of relative distance to schools or the spatial equity of school locations. Emily Talen (2001) engaged in a case study of school accessibility in three counties in West Virginia. The study empirically investigated the relationship between school locations and the students they serve in order to reveal if schools were equally accessible to residents based on population density and the socioeconomic status (SES) of residents. Talen's findings revealed that spatial inequities in access to schools were substantial; access to schools was not correlated with density of the population under 18.

Although the relationship between SES and school distance was inconclusive, she did find that there appeared to be “unpatterned inequality” and distance to school had a significant and an inverse relationship with 3rd grade test scores. Talen emphasized the need for more geographic research regarding school accessibility and the SES of the neighborhoods since catchment areas did not appear to reflect a “higher rational principle” in design.

2.5.3 School Attendance Boundaries in Las Cruces, New Mexico

Las Cruces, New Mexico is located in Doña Ana County, in the southern region of New Mexico, near the border of El Paso, Texas and Ciudad Juarez, Mexico. It is the second largest city in the state with a population of 101,408 residents, 57 percent of whom are of Hispanic/Latino origin and the remainder predominantly White Non-Hispanic (Bureau 2015). There is only one school district in the city, Las Cruces Public School District (LCPS), which is comprised of approximately 25,000 students, 75 percent of whom are Hispanic/Latino (LCPS 2014).

Las Cruces is a rapidly growing city due to its border location, which attracts migrant laborers, as well as people who work and study at New Mexico State University, the second largest university in the state. In fact, between 2000 and 2013, Las Cruces experienced a population increase of 37.7 percent (Blaich 2015). In 2015, population predictions estimated that by 2035, the population in Doña Ana

County[5] would increase by another 30 percent (BBER 2008). This is important to note, since public services will need to rise in tandem with population growth. It will be necessary to add new schools to the region and it is essential that the community, as well as education stakeholders, understand the importance of school zoning and its relationship with school diversity and equity. Without conscious, intentional zoning practices that encourage diversity and promote equity, the school district could potentially witness increasing amounts of segregation in coming years, and consequently, increasing social imbalance.

Since 2010, three new schools have been added to Las Cruces Public School District; an elementary school, a middle school, and a high school. The process of drawing new school attendance zones involves the district contracting a private GIS firm from Albuquerque, New Mexico to advise on future school site locations (Galvan 2016). Items they consider are; number of students and ages of students in neighborhoods, enrollment balance among the schools, traffic and major arterials, school bus transportation, natural boundaries, socioeconomic factors, predicted population and student-age enrollment growth rate, housing and projected housing, and birth rates. Afterwards, the district appoints a citizen-based committee to study multiple scenarios, provide feedback and to make recommendations to the

[5] Las Cruces is the largest city in the county, and approximately half of all county residents live in Las Cruces.

Superintendent and to the School Board. Ultimately, it is the School Board's decision on how to draw the boundary lines.

In 2009, Las Cruces planned the addition of two new schools to open in the fall of 2010; an elementary school and a middle school located in the East Mesa area of Las Cruces. A Redistricting Advisory Committee of 13 members was appointed to advise on the new boundary plan. (Husson 2009). The Board of Education established four criteria for the Committee to consider in the process:

1) Neighborhoods schools
2) Reflect the district's demographics
3) Address concerns of the community
4) Consider projected growth

The additional criteria suggested by the Committee were:

1. No school exceeds capacity during projected period
2. Minimize portable building use
3. Align feeder patterns
4. Consider transportation implications.

The Committee's plan for the middle school included approximately 6 percent more Hispanic/Latinos, 7 percent more English Language Learners and 8 percent more economically disadvantaged students than the district average (Committee 2009). Although it is unknown whether the plan was changed before implementation, the new school was placed in an area of town lacking a middle school but also containing some of the highest poverty rates in the district. Consequently, the original school the students were removed from, located in a more affluent area, saw a significant increase in the proportions of white non-Hispanics and a decrease in economically disadvantaged students. Only 30 percent of student achieved Adequate Yearly Progress (AYP) in reading proficiency at the new school, while the original school (where most of the students were pulled from), achieved 54 percent AYP, a 10 percent jump since the previous year (LCPS 2010; 2011).

Suggestions for the new elementary school were much more racially/ethnically and economically balanced. Consequently, the reading proficiency scores in the new elementary school the next year were compatible with the schools from which they were pulled. There was much debate when the new high school location was proposed in 2011, likely because high school zones are much larger than elementary and middle school zones and therefore affect a larger population. However, the primary community concerns during the high school redistricting process focused on how redrawing the boundaries would affect high school athletics, music, and band programs (Hunt 2011).

2.5.4 School Choice Landscape in Las Cruces Public Schools

Issues surrounding school segregation and diversity require understanding the school choice landscape in a school district; the types of alternative school options available and the potential a student has to attend a school outside of her or his geographically assigned school. According to Las Cruces Public School District policy, students are required to attend the school within their residential boundaries unless they obtain an approved transfer request from the school they wish to transfer into. At the time of this study period, acceptance of a transfer was contingent upon space availability, priority placement, and the ability of the parent or guardian to provide transportation to and from school (LCPS 2010).

LCPS recently made changes to this process, aligning themselves with the state instead of approving requests on a first-come, first-serve basis. The new state policy indicates school assignment preferences are first given to students who live in the attendance zone and then to those who attend a "F" rated school, as determined by the NM Public Education Department (LCPS 2017). Third priority for a transfer is if the student previously attended the school of choice. Military families and class size/space availability are the final priorities. All transfer requests must be submitted the spring semester before the upcoming school year (when the transfer is requested to take place). Las Cruces Public Schools receives hundreds of transfer requests however, as discussed earlier, most public-school students attend the school they are geographically assigned to.

There is only one charter school in Las Cruces that serves elementary age children. J. Paul Taylor Academy opened in the 2011-2012 school year with a projected enrollment of 140 students, spanning grades K-6 in its first year, then adding another grade for the next two years, increasing twenty students per year, until it reached a cap of 180 students serving grades K-8 (Academy 2010). There is also a small selection of private schools in Las Cruces that served approximately 6 percent of the total children enrolled in grades K-4, between 2010-2014 (U.S. Census Bureau 2014). This roughly agrees with estimates by the National Center for Education Statistics that state approximately nine out of every ten American children attend public schools (NCES, Common Core of Data Quickfacts 2016).

2.6 Key Points of the Literature Review

The significant relationship between school segregation and school catchment zones beckons the need for more analyses employing the use of spatial tools, investigating the relationship between school zoning and how this related to school socioeconomic segregation, and consequently academic achievement. The lack of analyses examining the poverty rates within zones and Hispanic/Latino segregation in the Southwest, which follows different patterns than in the rest of the United States, highlights the importance of this study. Furthermore, as Las Cruces Public School District continues to grow, it will be necessary to add additional public schools. In fact, the LCPS redistricting report estimated that by the 2018-2019 school year, approximately nine elementary schools would be over capacity (Committee 2009).

These factors demonstrate the usefulness of this study, and the importance for school districts to develop well planned guidelines on school district zoning that emphasize socioeconomic diversity in the schools. The demographic composition of neighborhoods within school attendance zones should be a priority when drawing school attendance boundaries. By neglecting to draw school attendance boundaries with a diverse socioeconomic composition, segregation is bound to proliferate as the population grows.

3. Hypotheses

H_1: The racial/ethnic composition of each school attendance zone will reflect the racial/ethnic composition of the school assigned to that zone.

H_2: The socioeconomic composition of school attendance zones will not reflect the overall socioeconomic composition of the school district; there will be segregation between elementary schools in Las Cruces Public School District.

H_3: Academic performance will be a function of the socioeconomic composition of a school attendance zone; higher rates of minority and/or low-income students in a zone will be inversely related to academic achievement.

H_4: The higher the percentage of Hispanic/Latinos in a neighborhood along a school attendance boundary, the higher the likelihood they will attend a low performing school. Likewise, the higher the percentage of poverty in a neighborhood along a school attendance boundary, the higher the likelihood they will attend a low performing school.

H_5: The socioeconomic composition of existing school attendance zones will be more diverse than school attendance zones more centrally located around a school point location (Thiessen polygons).

4. METHODOLOGY

4.1 Strategy and Design

This study uses various quantitative geospatial and aspatial methods to examine the relationship between the socioeconomic composition of school attendance zones and the socioeconomic composition and academic performance of the twenty-three elementary schools assigned to those zones. The research questions for this study are explored through the specific methods outlined in Table 3 and explained in detail in Section 9.

Table 3: Objectives/Research Questions and methods used in the analysis.

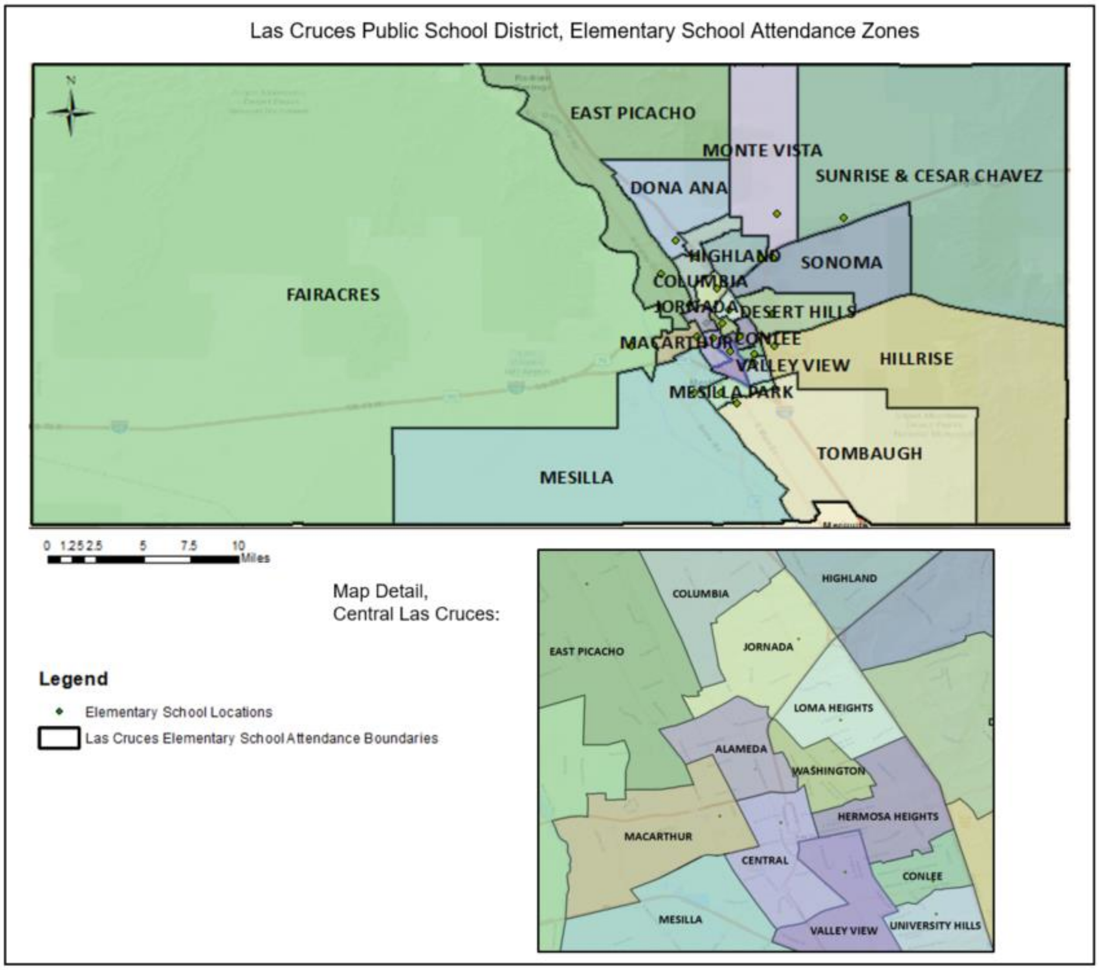
Objectives (RQ's)	Methods
1) Measure the racial/ethnic composition in SAZs as related to their assigned school.	Pearson's Correlation Analysis to compare racial/ethnic composition of zones to the corresponding schools.
2) Measure the degree to which elementary schools and school attendance zones (SAZs) in Las Cruces Public School District are segregated.	Boundary Intersect Interpolation to aggregate data within SAZs. Measure degree of segregation between zones and the overall district with Theil's Entropy Index and Dissimilarity Index.
3) Determine if academic performance is a function of the socioeconomic composition of schools and SAZs.	Linear Regressions and Geographically Weighted Regression using poverty and minority rates as independent variables and academic performance as the dependent variable.
4) Determine if the socioeconomic composition of a neighborhood predicts its inclusion into a low or high performing school.	Spatial autocorrelation to identify spatial patterns of segregation in census blocks and block groups. Paired sample T-Tests to analyze the differences between the socioeconomic composition of neighborhoods along boundaries of low and high performing schools.
5) Measure the degree to which existing zones are more or less diverse than alternate models where SAZs are centrally located around their school.	Create Thiessen Polygons as alternate models. Compare the socioeconomic composition of current SAZs with the socioeconomic composition of models using Theil's Index and Dissimilaruty Index to compare possible patterns in segregation.

4.2 Sample

The sample consists of 23 elementary schools and their attendance boundary zones (school catchment areas/zones) for Las Cruces Public Schools (Figure 4). The units of analysis are the schools and the blocks and block groups within the school catchment areas. One elementary school, White Sands Elementary, was removed from the study because White Sands Elementary is located on a military base and does not represent a typical school catchment zone/Census area. Another school, Cesar Chavez Elementary is a Kindergarten thru 2nd grade feeder school for Sunrise

Elementary which serves 3rd grade thru 5th grade. Both schools share the same catchment zone and their school level data were combined for this study.

Figure 4**:** Las Cruces Public School District, Elementary School Attendance Zones



Source: LCPS Boundary Files and ESRI

The rationale for choosing this purposive and sequential sample was to examine issues of segregation in a growing metropolitan city with a large Hispanic/Latino population in the Southwest. In addition, this study sought to explore whether the socioeconomic composition of elementary school attendance zones in Las Cruces Public School District reflect the socioeconomic composition of the overall district and the demographic diversity of the elementary schools and school attendance zones. This sample also examined the relationship between the socioeconomic composition of school attendance zones and academic proficiency of students in the schools they serve. Neighborhood sample selections among blocks and block groups sharing a common boundary are purposive in nature since the intention is to measure difference between catchment zones assigned to high or low performing schools. This sample is also built upon previous literature questioning whether neighborhoods located along a shared school attendance boundary line (but are assigned to different schools) are demographically similar or different (Bischoff 2008).

This sample does not intend to be representative of the entire country, only as a possible proxy for populations with similar demographics to this sample and that can inform patterns in Hispanic segregation. This study also seeks to contribute to literature on useful methods for spatially analyzing attendance zones and assist school districts and policy makers in making well informed decisions when drawing boundaries.

4.3 Data

Building maps in which to overlay socioeconomic data requires gathering geospatial and aspatial data from various sources. GIS shapefiles of attendance zone boundaries were obtained from Las Cruces Public School District. Census block and block group shapefiles were retrieved from the Census Bureau's MAF/TIGER database. The National Historical Geographic Information System (NHGIS) provides aggregate Census data and GIS-compatible boundary files for the United States between 1790 and 2014, which can be joined with GIS shapefiles from the Census Bureau (Minnesota 2016). Although socioeconomic data can be directly downloaded from the Census, the NHGIS makes filtering specific city socioeconomic data down to block/ block group level less cumbersome, and the files are already prepared for making joins in ArcGIS.

The socioeconomic composition of the school attendance zones and the district zone consisted of the poverty rates and race/ethnic composition. These were obtained from two different Census units; blocks and block groups. The smallest unit of observation for Census data is at the block level taken from the 2010 Decennial Census. Five attributes can be extracted at this level; number of people per block and their distribution by age, sex, race, and Hispanic origin (Saporito, Chavers, et al. 2007). I collected race and ethnicity data from table P12I. Sex by Age (White Alone, Not Hispanic or Latino) from Summary File 1 at the block level. Poverty data are not captured at the block level but can be obtained at the next higher level, block group.

The 2010-2014 American Community Survey Census Table: B17010: Poverty Status in the Past 12 Months of Families by Family Type by Presence of Related Children Under 18 Years by Age of Related Children was used for this study.

Data measuring school proficiency, a combined average of 3rd grade Standards Based Assessment (SBA) scores for English and math was accessed through the New Mexico Public Education Department for four academic years; 2010-2011, 2011-2012, 2012-2013 and 2013-2014. These sets of scores correspond to the Census data time frame in the study.

Data regarding the socioeconomic composition of the schools, student race/ethnicity counts and students receiving free or reduced-price lunch was retrieved from the National Center for Education Statistics, Common Core of Data (CCD). Table 4 outlines the types of data used for all indicators.

Table 4 Spatial, Census Level Data and School Level Data Used in the Analyses

Type of Data	Spatial Census Level Data	School Level Data
Poverty Rate	2010-2014 ACS Census Table B17010 Poverty Status in the Past 12 Months of Presence of Related Children Under 18 Years of Age.	NCES (CCD), Free and Reduced Price Lunch data 2010-2014 for descriptive statistics.
Race-Ethnicity (Minority, Non-Minority)	2010 Census Bureau, SF1, Table P12I: Sex by Age. Children between the ages of 5-9 and all children under 18 years of age.	NCES (CCD), K-3rd grade student race/ethnicity data- 2010-2011 for RQ1, 2010-2014 for descriptive statistics.
School Proficiency		NMPED, Combined average of 3rd grade SBA scores for English & Math 2010-2014.
School Attendance Zone Shapefiles	LCPS attendance boundary shapefiles.	
Census Data Shapefiles	Census block and block group shapefiles- Census Bureau MAF/TIGER database.	

5. MEASURES

5.1 Minority Status

Geographic level minority status

Percent minority/non-minority was calculated to determine the percent white non- Hispanic and is referred to as “non-minority.” Likewise, the percent of the population that is minority was defined as the percent of the population that is of Hispanic/Latino ethnicity and was combined with all other races except white non-Hispanic/Latino. This was reasonable considering the population of all other races in the region is statistically very small compared to white non-Hispanic/Latino and the

Hispanic/Latino population. The race and ethnicity data among households with children between the ages of 5-9 years-old was calculated for Research Question 1 and compared to the percentage of minority children in grades K thru 3rd grade for the 2010-2011 school year since this most closely corresponds to the race and ethnicity data pulled from the 2010 Census. Since the source of the minority data was from the 2010 Census, I used the equivalent 2010-2011 school year as the percentage minority from the National Center of Educational Statistics (NCES) Elementary/Secondary Information System (ELSi) for the schools. Initially this study proposed using race and ethnicity data among households with children between the ages of 5-9 for all analyses, since that is the Census age group that most closely reflects the ages of elementary school students and this is the group that has been used in previous research (Saporito and Sohoni 2006). However, several spatial analyses required using all children under 18 years of age as a measure because of the lack of population density in the district.[6]

<u>School level minority status</u>

Similarly, percent minority/non-minority was calculated to determine the percent white non- Hispanic and will be referred to as “non-minority.” Likewise, the percent of the population that was minority was defined as the percent of the population that is of Hispanic/Latino ethnicity and was combined with all other races

[6] For further explanation, please see section 7 “Limitations.”

except white non-Hispanic/Latino. School level minority status was retrieved from the National Center of Educational Statistics (NCES) Common Core of Data (CCD). This data consisted of the average minority/non-minority rates for students in grades K-3 since the ages of students in these grades most closely matched the age grouping for the Census data (ages 5-9) used for Research Question 1. In addition, these data were taken from the 2010-2011 school year for Research Question 1, the same year as the 2010 Census data. For all other research questions, a combined average of student demographic data for four academic years, between 2010 and 2014, was used.

5.2 Poverty

Geographic level poverty

The poverty rate was calculated from the 2010-2014 American Community Survey Census Table: B17010. Poverty Status in the Past 12 Months of Families by Family Type by Presence of Related Children Under 18 Years by Age of Related Children. This data is available at the census block group level. All children under 18 within each school attendance zone were included since the under 18 category often serves as a proxy for all age groups under eighteen regardless of school level. Essentially, the demographic composition of neighborhoods, regarding race/ethnicity or poverty status, does not change significantly whether the unit of analysis is elementary, middle, or high school students.

School level poverty

Data regarding the poverty rates of the schools (for general descriptive statistics) was based on the percentage of students in schools receiving free lunches. A student qualifies if their family earns less than 130 percent of the Federal Poverty Level (FPL) and a reduced priced lunch is their family income is between 130 percent and up to185 percent of the FPL. These data were retrieved from the National Center of Educational Statistics Common Core of Data (CCD). These data resulted in a combined average of students on free and reduced-price lunches for four academic years; 2010-2011, 2011-2012, 2012-2013 and 2013-2014.

5.3 School Proficiency

School proficiency (also referred to as low performing or high performing school) was a combined average of 3rd grade Standards Based Assessment (SBA) scores for English and math obtained from the New Mexico Public Education Department for four academic years; 2010-2011, 2011-2012, 2012-2013 and 2013-2014.

6. Data Analysis Process

The first step in building the maps required uploading Las Cruces Public School attendance zone shapefiles into ArcGIS desktop software. After calculating the poverty rates at block group level and the race/ethnicity data at block level, the Census data tables were joined with the attendance boundary shapefiles in ArcGIS. This resulted in a new map with race/ethnicity and poverty data layered on top of block and block group units of analysis. Although blocks for the most part nested fairly neatly within school attendance boundaries allowing the total percent minority vs. non-minority to be calculated, block groups did not nest neatly within school attendance boundaries. School attendance zones often cut through block groups.

One way of coping with source data (in this example Census data) that is incongruent with the target unit (school attendance zones) is by employing interpolation methods (Saporito, Chavers, et al. 2007). There are four typical interpolation methods used to analyze Census data, the population weighting method, areal weighting method, 50 percent weighting method, and the boundary intersection method. The population weighted interpolation is the method recommended by Saporito and Chavers, et al. since it assigns the weight of the population at the block level to the proportion of the block group within its school catchment zone. However, the majority of block groups that required interpolation in this study were very large and located on the outskirts of the school district. The population in these block groups is sparse with corresponding blocks shaped in a similar manner. These blocks overlap boundaries so there is no great advantage to using this methodology over the others.

In addition, Saporito and Chavers et al. compared the four interpolation methods against known population statistics using correlation coefficients and found the mean correlation coefficients for all methods above .962. Although the team found the population weighting method most accurate, the high correlation coefficients suggest all methods are highly accurate. In addition, the largest difference between the interpolation techniques was only .033, hardly a cause for concern. The boundary intersect method was chosen for this analysis since it is one of the least complicated techniques, and the other methods appeared to have no advantage when applied to this particular study area. Analyses that were aspatial in nature were run using a combination of SAS Enterprise Guide, Microsoft Excel, SPSS, and Tableau software.

7. LIMITATIONS

A limitation of this study compared to previous school attendance zone and district zone studies was the sample size and sparse distribution of spatial units. Although I knew the overall sample size was smaller than the ideal minimum, I did not foresee that the spatial units would also create a challenge. Prior studies were conducted in major metropolitan areas with high population density that likely did not present any special challenges. By comparison, the Las Cruces Public School District population is relatively small and is spread over a large geographic area. Roughly 25,000 students attend Las Cruces Public Schools within a geography of 1,463 square miles. To put this in perspective, approximately 135,000 students attend San Diego Unified School District within 354.1 square miles and 1,031,000 students attend New York Public Schools across 302.6 square miles. Consequently, both the small number of students and small number of attendance zones coupled with a large geographic study area, made statistical tests, especially spatial analyses, more challenging than a typical study.

This sparsely populated area required adapting units of analysis, such as choosing all children under 18 instead of children 5-9 within Census blocks/ block groups necessary for most spatial analyses to increase spatial distribution and power. Regardless, previous research supports the use of the grouping, children under 18 years-old, as a proxy for other age groups since the demographic composition of neighborhoods, regarding race/ethnicity (or poverty status), does not change significantly whether the unit of analysis is elementary, middle, or high school students. This was further confirmed with a Pearson's Correlation Analysis I conducted between minorities ages 5-9 years-old in the zones with minorities under 18 years-old in the zones. This resulted in a Pearson's r of 0.99, revealing virtually no difference between the two age groups.

In addition, although the population weighted interpolation method often offers a finer level of analysis on a densely populated geographic area, the lack of density made this method difficult and inappropriate to employ so the simpler, boundary intersection method was used. Another limitation is the fact that although the majority of Census blocks nestle within their school attendance boundary, the size and shape of the blocks were inconsistent and were not easily comparable due to the expansive geographic landscape. This obstacle required me to abandon regression analyses intended to measure the likelihood that a student would be assigned to a low or high performing school based on the demographics of their neighborhood. Instead, I identified high and low performing schools that shared a common school attendance boundary and conducted a paired sample t-test to compare the differences between the demographics in blocks (or block groups) located along the perimeters of these matched school attendance zones.

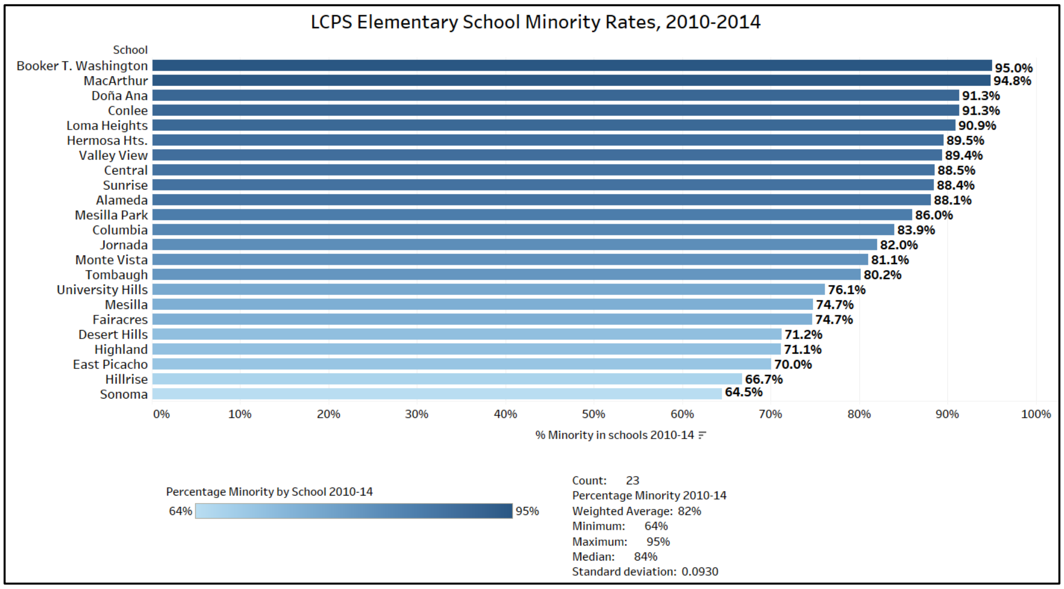
Another obstacle was the differences in poverty measurements at school level versus geographic (Census) level. At the geographic level, poverty was measured by children living below 100 percent of the Federal Poverty Level, whereas at the school level it is measured by students on a free or reduced-price lunch. The latter includes children up to 185 percent of the Federal Poverty Level. This is a vast difference. Consequently, the maps are slightly misleading; they show much lower levels of poverty than are actually present in the zones. Likewise, the fact that poverty can only be measured at block group level presents an additional challenge. As stated earlier, the district covers a large geographic area. The central part of the district is densely populated and the block groups are manageable in size. However, block groups on the outskirts of the city can be extremely large. This introduces what is known as the modifiable areal unit problem (MAUP). There are two components to MAUP; one regards scale; the level of aggregation of data analyzed, and the other zoning; how the boundaries or zones within which the data nests, are defined and analyzed (Fotheringham and Wong 1990). It is possible some of the largest block groups on the outskirts of the city, which cover a larger geographic area, may have more variability than what appears in the numbers. This should be kept in mind when interpreting results. Although these limitations are important to take into consideration, they should not undermine the overarching findings.

8. RESULTS

8.1 Descriptive Statistics: School Level

Figures 5 and 6 present the average percentage minority and poverty rates in each of the elementary schools while Table 5 displays the means for all three variables for school level data, poverty, minority and proficiency rates. Descriptive statistics for all variable at district level are provided in Table 6.

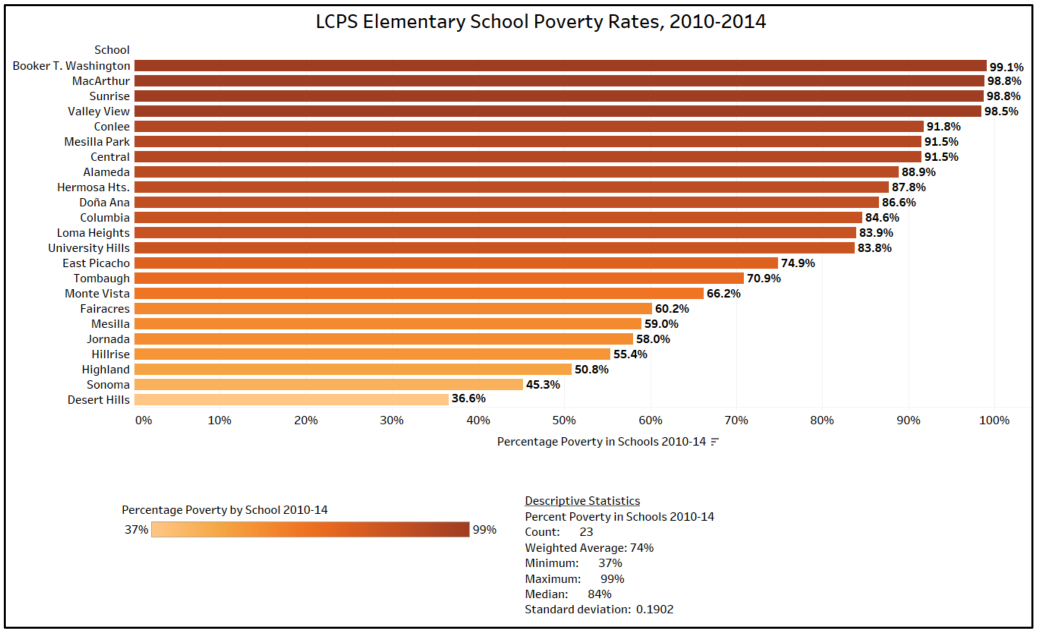
Figure 5: LCPS, Elementary School Minority Rates, K-3rd Grade



Source: National Center for Educational Statistics (NCES)

The graphs tell us that minorities are the statistical majority in all schools and the range in values between the school with the highest minority rate, Booker T. Washington, and the school with the lowest minority rate, Sonoma, is 30.5 percent. The range in values between the school with the highest poverty rate, Booker T. Washington, and lowest poverty rate, Desert Hills, is 62.5 percent, which is larger than the range in values for minority rates. This indicates the majority of students in the schools are minorities and there are considerable differences in the levels of poverty in the schools.

Figure 6: LCPS, Elementary School Poverty Rates, Grades K-3rd



Source: National Center for Educational Statistics (NCES)

Table 5: Mean Minority, Poverty, and Academic Proficiency Rates in Schools, Grades K-3rd

School	% Minority	% Poverty	% Proficient
Booker T. Washington	95.0%	99.1%	44.5%
MacArthur	94.8%	98.8%	42.6%
Doña Ana	91.3%	86.6%	45.1%
Conlee	91.3%	91.8%	41.5%
Loma Heights	90.9%	83.9%	49.0%
Hermosa Hts.	89.5%	87.8%	37.7%
Valley View	89.4%	98.5%	46.7%
Central	88.5%	91.5%	44.5%
Sunrise	88.4%	98.8%	44.2%
Alameda	88.1%	88.9%	37.4%
Mesilla Park	86.0%	91.5%	53.3%
Columbia	83.9%	84.6%	38.8%
Jornada	82.0%	58.0%	48.1%
Monte Vista	81.1%	66.2%	66.7%
Tombaugh	80.2%	70.9%	55.5%
University Hills	76.1%	83.8%	58.8%
Mesilla	74.7%	59.0%	50.9%
Fairacres	74.7%	60.2%	57.4%
Desert Hills	71.2%	36.6%	74.0%
Highland	71.1%	50.8%	58.4%
East Picacho	70.0%	74.9%	51.1%
Hillrise	66.7%	55.4%	66.6%
Sonoma	64.5%	45.3%	65.8%

Source: National Center for Educational Statistics (NCES)

Table 6: Mean Minority, Poverty, and Academic Proficiency Rates in District, Grades K-3rd

	Poverty in Schools	*Minority in Schools*	*Proficiency in Schools*
Mean	0.74	0.821	0.512
Median	0.838	0.839	0.489
Standard Deviation	0.191	0.093	0.101
Range	0.625	0.305	0.366
Minimum	0.365	0.644	0.374
Maximum	0.99	0.949	0.74
Skewness	-0.584	-0.42	0.626
Kurtosis	-0.868	-1.09	-0.403
Shapiro-Wilk	.910*	0.93	0.943
N	23	23	23

* p = .04

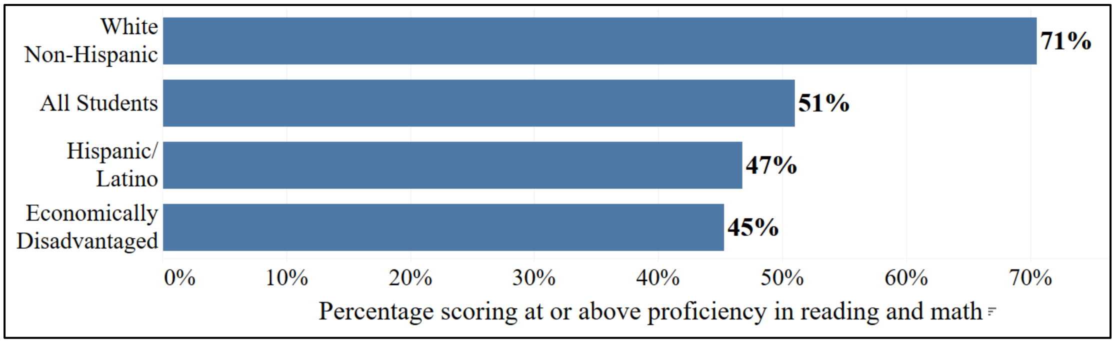
Source: National Center for Educational Statistics (NCES)

The three data sets were checked for normality. The Shapiro-Wilk test was used since the data sets had less than 50 cases. This test indicates whether the data are significantly different from a normal distribution. Among the three school level data sets, the percentage poverty in the school was the only data set that deviated from normality. The test statistic for poverty in the schools is .910 with a p value of .04, slightly less than .05, suggesting the data is not normally distributed. However, examining this further, the skewness statistic is -.584 indicating the data is only moderately skewed to the left of a normal distribution. In addition, the kurtosis is -.868 indicating the distribution is platykurtic, somewhat uniform, with less frequent extremes in deviations. In addition, the percentage minority in the schools is approximately symmetric with a platykurtic distribution while student proficiency is moderately skewed to the right with a platykurtic distribution.

The National Center for Educational Statistics defines high-poverty schools as public schools where more than 75 percent of the students are eligible for free or reduced-price lunch (FRPL), mid-high poverty schools are those where 50.1 to 75 percent of students qualify for FRPL, low-poverty schools are schools where 25 percent or less of the students are eligible for FRPL, and mid-low poverty schools are schools where 25.1 to 50.0 percent of the students are eligible for FRPL (NCES 2017). By this measure, no schools in LCPS district are low poverty schools, 11 schools fall into the mid-low and mid-high poverty categories, and the remaining 13 schools would be considered high-poverty schools. This is not unexpected considering nearly half of all Hispanic students in the United States attend high-poverty schools compared to only 8 percent of white non-Hispanic students (NCES:1).

The average proficiency rate in the district was 51 percent and the median, 49 percent. Figure 7 compares the average rates of proficiency between all 3rd graders in the district. The proficiency rate for white non-Hispanics was 20 percent higher than the average, while the proficiency rate for Hispanic/ Latinos was 4 percent lower than the average, and 6 percent lower than average for economically disadvantaged students.

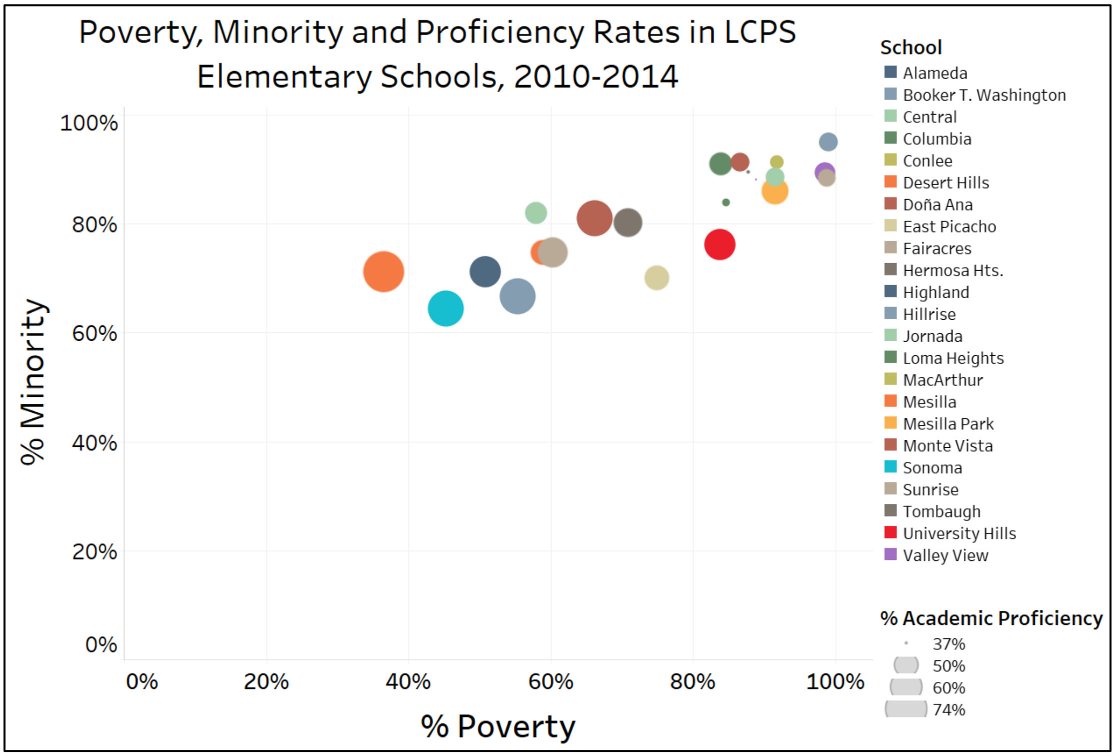
Figure 7: Las Cruces Public School District, 3rd Grade Academic Proficiency Rates by Demographic 2010-2014



Source: National Center for Educational Statistics (NCES)

A comparison of the three variables indicates schools with the higher than average proficiency rates are the schools with the lowest poverty rates such as Desert Hills and Sonoma Elementary. A bubble chart of all three variables; poverty rates, minority rates, and proficiency rates illustrates their relationship (Figure 8).

Figure 8: LCPS, Elementary School Poverty Rates, Minority Rates and Proficiency Rates, Grades K-3rd.



Source: National Center for Educational Statistics (NCES)

The higher the poverty rate in the school, the higher the minority rate as well. The size of the bubbles (schools) represent the proficiency rate of the school. The larger the bubble, the higher the reading and math average score amongst kindergarten to 3rd grade students. The graph shows that the schools with the highest proficiency scores tend to have lower minority and poverty rates.

Correlation analyses also demonstrated the strengths of the relationships between the various variables (Table 7). The analysis showed a significant relationship between minority and poverty rates with a Pearson's correlation coefficient (r) of 0.859 and $p < .0001$. These socioeconomic factors (minority and poverty rates) are also significantly related to academic proficiency, with a Pearson's r of -0.773, $p < .01$ and -0.788, $p <.01$ respectively.

Table 7: LCPS Elementary Schools, Pearson's r Correlations; Poverty Rates, Minority Rates and Proficiency Rates, Grades K-3rd

Correlation Coefficients

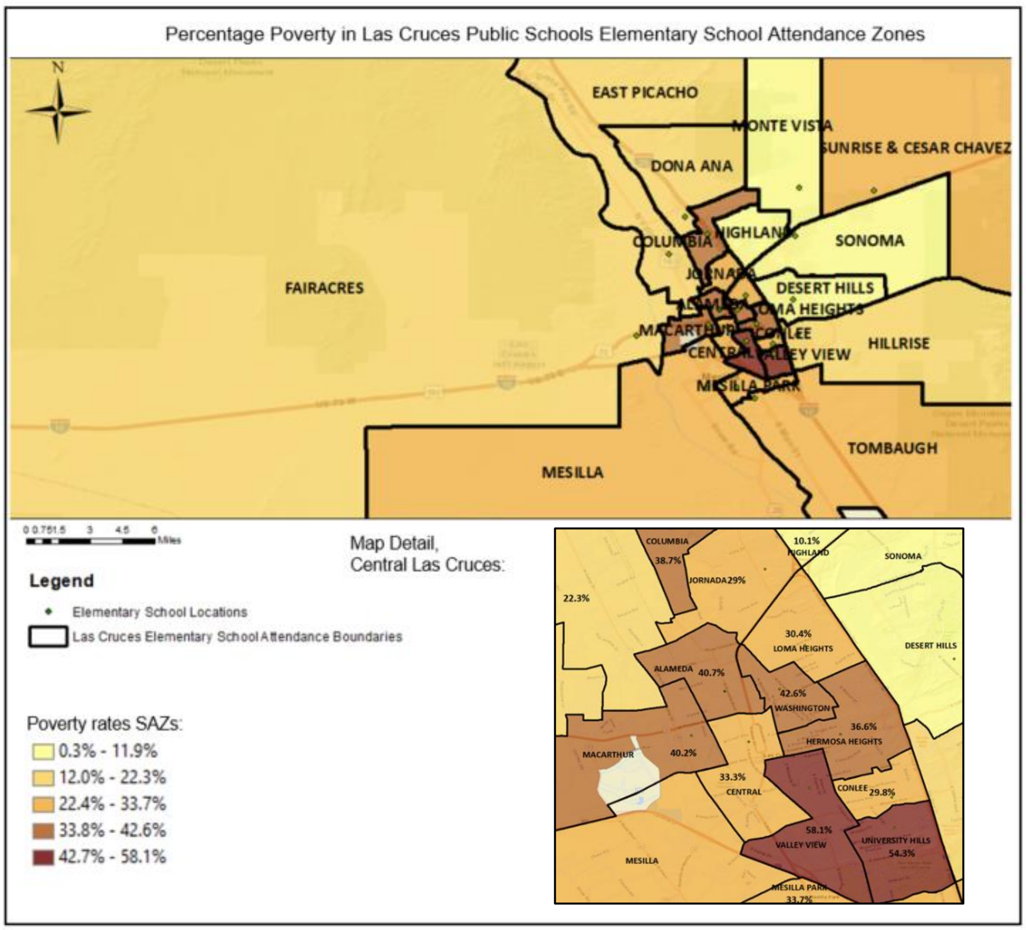
	Academic Proficiency	Minority Rates	Poverty Rates
Academic Proficiency	1.00	-0.773**	-0.788**
		[-0.895, -0.516]	[-0.902, -0.543]
Minority Rates		1.00	0.86**
			[0.682, 0.936]
Poverty Rates	-.788**	.86**	1.00

N= 23,**p < .01, CIs reported in brackets

8.2 Descriptive Statistics: Geospatial Level

The next step was to explore the school attendance zones in maps. This involved calculating the variables of interest from the US Census Bureau in Excel databases, in this case the percentage of children living in poverty within bock groups and minority status at the block level, in various age categories. After preparing the data, the shapefiles were uploaded into ArcGIS. These included shapefiles of Las Cruces Public School District school attendance zones, a shapefile containing point locations of the schools, and shapefiles of the block groups and blocks in Las Cruces. The socioeconomic Excel data files were prepared then joined with shapefiles of the school attendance boundaries in Las Cruces Public School District. The data were then interpolated to aggregate the data within each school attendance zone. Figure 9 illustrates the poverty rates in the school attendance zones.

Figure 9: Poverty Rates, Children under 18 years-old, LCPS Elementary School Attendance Zones

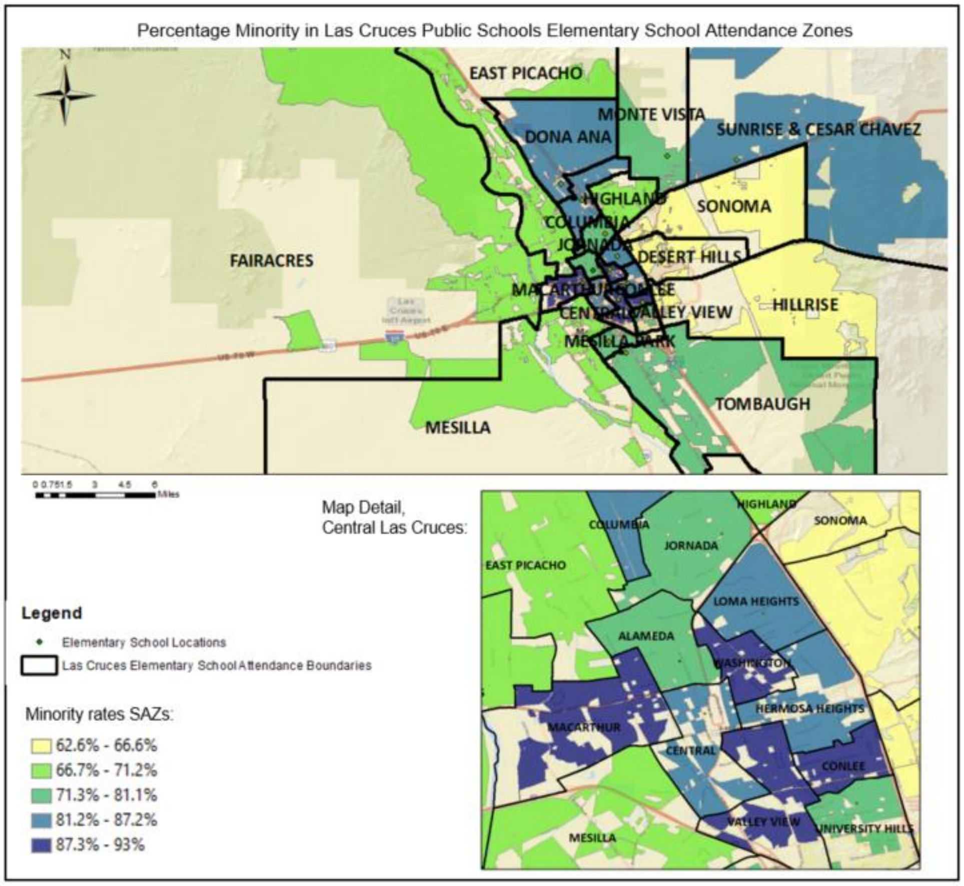


Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

The central area of the district has higher poverty rates while the zones slightly northeast have lower poverty rates. Although these rates are much lower than seen in the schools because they are measured differently, proportionally they are similar with nearly the same range. For example, schools such as Desert Hills and Sonoma have much lower rates of poverty than the overall district while schools in the central region have higher poverty rates.

Minority rates follow similar patterns with the lowest minority rates in Sonoma, Desert Hills, and Hillrise. The highest concentrations of minorities reside in the central region of the city (Figure 10).

Figure 10: Minority Rates, Children under 18 years-old, LCPS Elementary School Attendance Zones



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Table 8 presents basic descriptive statistics for children living within the geographic area of the entire district and Table 9 presents the means for the individual school zones. The overall poverty mean is approximately 29 percent with a range of approximately 58 percent. The average minority rate in the district is much higher at 79 percent with a smaller range of 30 percent.

Table 8: Descriptive Statistics: Poverty and Minority Rates by School Attendance zone

	Poverty in School Attendance Zones	*Minority in School Attendance Zones*
Mean	0.286	0.789
Standard Error	0.030	0.019
Median	0.299	0.797
Standard Deviation	0.143	0.091
Range	0.578	0.304
Minimum	0.003	0.626
Maximum	0.581	0.930
Skewness	0.028	-0.234
Kurtosis	-0.031	-1.148
Shapiro-Wilk	0.984	0.952
N	23	23

r = .656

Table 9: Mean Poverty and Minority Rates by School Attendance Zone

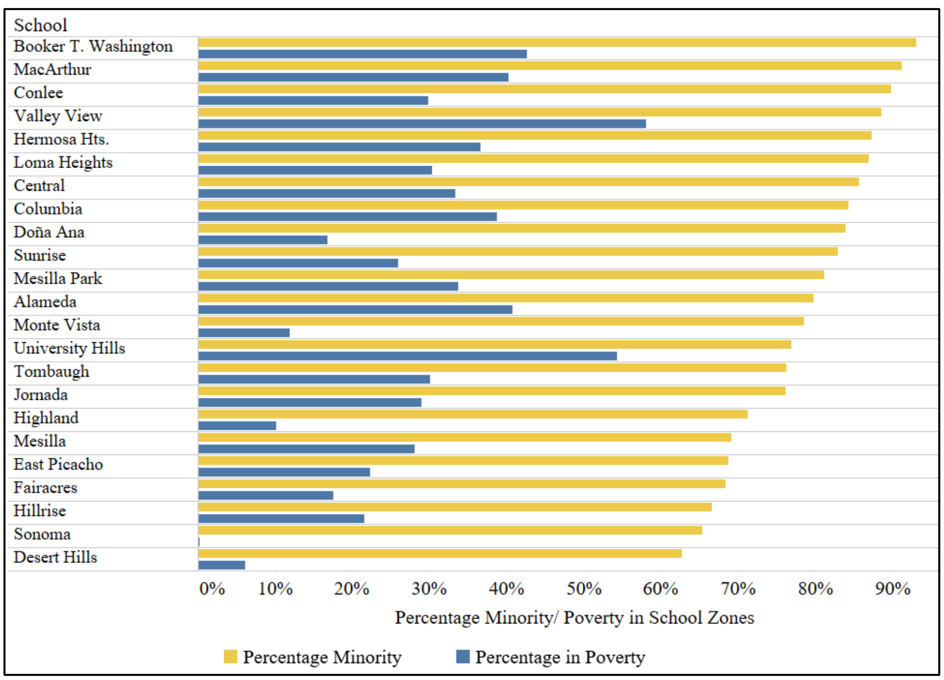
	Mean Poverty in Zones	*Mean Minority in Zones*
ALAMEDA	41%	80%
BOOKER T. WASHINGTON	43%	93%
CENTRAL	33%	86%
COLUMBIA	39%	84%
CONLEE	30%	90%
DESERT HILLS	6%	63%
DONA ANA	17%	84%
EAST PICACHO	22%	69%
FAIRACRES	18%	68%
HERMOSA HEIGHTS	37%	87%
HIGHLAND	10%	71%
HILLRISE	22%	67%
JORNADA	29%	76%
LOMA HEIGHTS	30%	87%
MACARTHUR	40%	91%
MESILLA	28%	69%
MESILLA PARK	34%	81%
MONTE VISTA	12%	78%
SONOMA	0%	65%
SUNRISE	26%	83%
TOMBAUGH	30%	76%
UNIVERSITY HILLS	54%	77%
VALLEY VIEW	58%	89%

Source: National Center for Educational Statistics (NCES)

Tests for normality indicate that both data sets are normally distributed. The percentage poverty in the zones is almost perfectly symmetrical and there is only a slight amount of excess kurtosis. Likewise, the percentage minority in the zones is almost symmetrical and only slightly platykurtic (-1.148), meaning the distribution is fairly uniform.

The statistics indicate poverty in the zones is much lower than the minority rates in the zones as illustrated in Figure 11. It is important to remember that poverty levels in the zones are much lower than those in the actual schools because the zones represent a different measure of poverty.

Figure 11: Minority Rates in School Attendance Zones Compared to Poverty Rates in School Attendance Zones



Source: National Center for Educational Statistics (NCES)

8.3 Measuring the racial/ethnic composition of each school attendance zone as related to the racial/ethnic composition of the school assigned to that zone.

The racial/ethnic composition of zones and their assigned schools were compared to see if they reflected each other. The purpose of this analysis was to determine if the racial/ethnic composition of the zones and their geographically assigned schools match. This identified whether students within a zone were attending their geographically assigned school. Although it is assumed most students attend their geographically assigned school, past research indicates that in some cases, other school options pull white non-Hispanic students into charter, magnet, or private schools, especially the closer a catchment area gets to being 50 percent white and 50 percent non-white (Saporito and Sohoni 2006). This step essentially verified that I was comparing compatible units of analysis as well as identifying any possible anomalies between school catchment zones and school attendance patterns.

For this analysis, I compared the average minority rates in the schools, grades kindergarten to 3rd grade to the minority rates for children ages 5 to 9 years-old living at Census block level. Pearson's Correlation Coefficient Analysis measured the strength of the association between the racial/ethnic composition in the schools compared to the zone. The results indicated and correlation coefficient r of 0.957 and a p value = 0.001, demonstrating a very strong and significant relationship between the percentage of Minority in Schools and the Percentage of Minority in the Zones (Table 10).

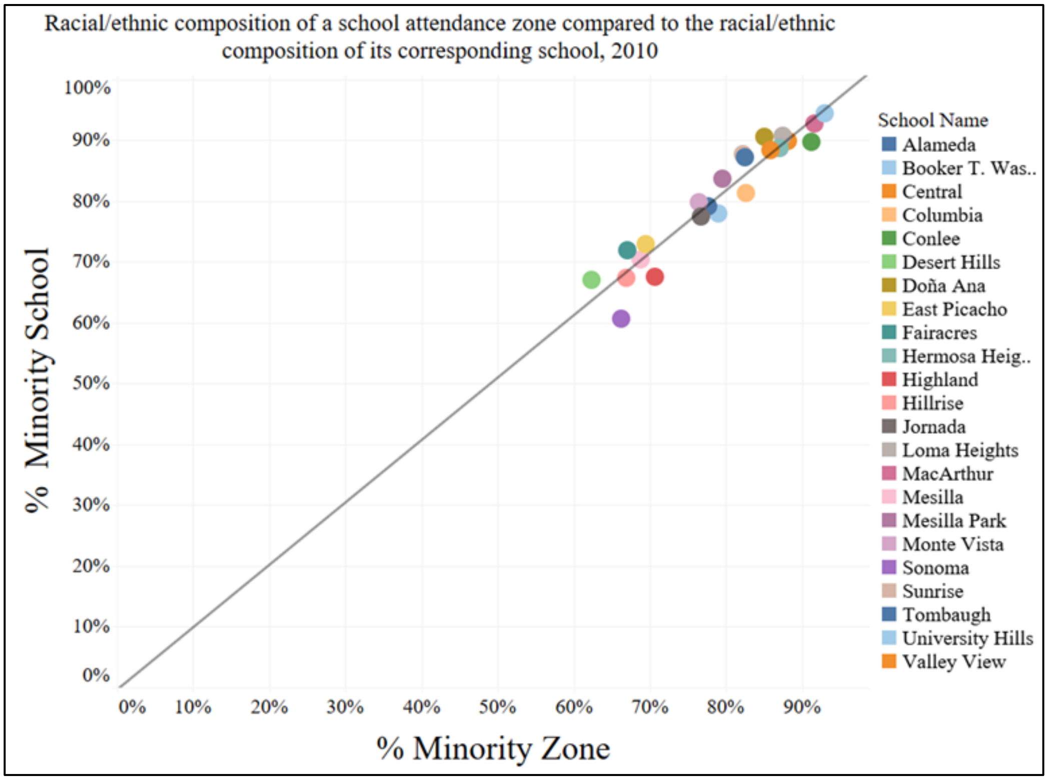
Table 10: Correlation Analysis Minority Rates in School Attendance Zones and Minority Rates in Schools

	% Minority in School	% Minority in Zone (5-9)
% Minority in School (K-3rd Grades)	1	
% Minority in Zone (5-9)	0.957**	1

**$p < .001$

These results suggest most students are attending their assigned schools. The scatterplot in Figure 12 comparing the percentage minority in the zones with the percentage minority in the schools shows the correlation fitted along a linear model trend line. If all minority children attended the school they were assigned to, the proportion of minorities in a school should closely match the proportion of minorities in the school's attendance zone. The dots placed closely along the scatterplot line suggests students are likely attending the school they are geographically assigned to. Table 11 further illustrates this by comparing the minority rates in the schools to the minority rates in the school attendance zones, and the percentage difference between them.

Figure 12: Percentage Minority in the Schools Compared to Percentage Minority in School Attendance Zones



Source: National Center for Educational Statistics (NCES) 2010, US Census Bureau 2010

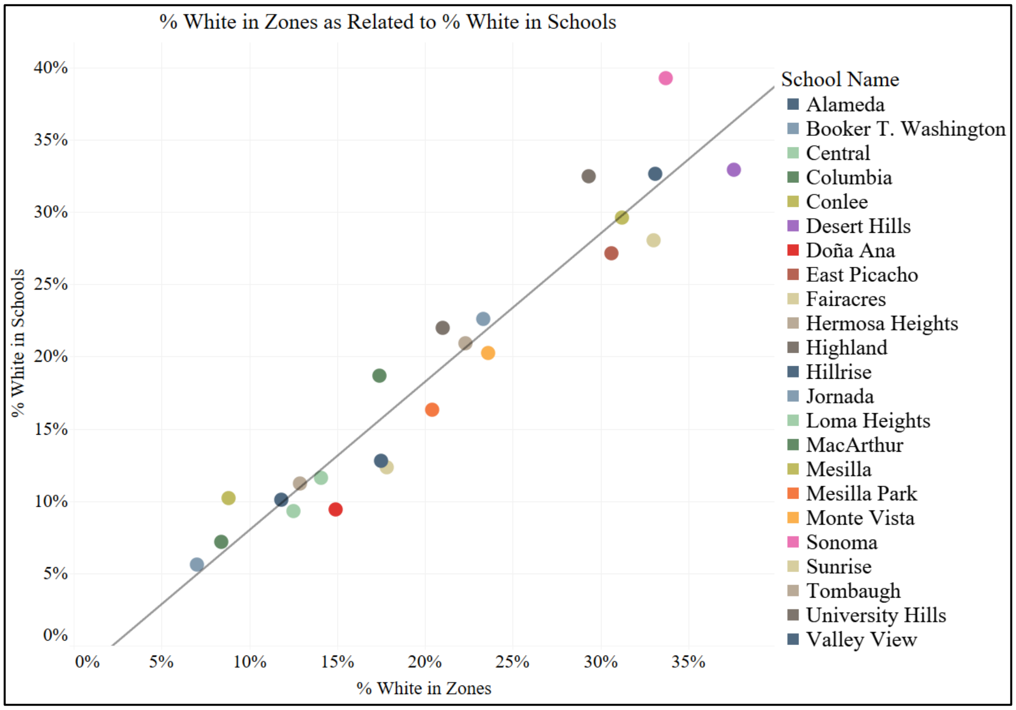
Table 11: Percentage Minority in Zones, Percentage Minority in the Schools, and their Difference

School Name	% Minority Zone	% Minority School	% difference
Doña Ana	85%	91%	-5.49%
Sunrise	82%	88%	-5.47%
Fairacres	67%	72%	-4.94%
Alameda	83%	87%	-4.70%
Desert Hills	62%	67%	-4.65%
Mesilla Park	80%	84%	-4.10%
East Picacho	69%	73%	-3.48%
Monte Vista	76%	80%	-3.36%
Loma Heights	88%	91%	-3.17%
Central	86%	88%	-2.47%
Valley View	88%	90%	-1.73%
Hermosa Heights	87%	89%	-1.69%
Mesilla	69%	70%	-1.57%
Booker T. Washington	93%	94%	-1.40%
Tombaugh	78%	79%	-1.38%
MacArthur	92%	93%	-1.21%
Jornada	77%	77%	-0.71%
Hillrise	67%	67%	-0.47%
University Hills	79%	78%	1.01%
Columbia	83%	81%	1.27%
Conlee	91%	90%	1.39%
Highland	71%	68%	3.17%
Sonoma	66%	61%	5.57%

Source: National Center for Educational Statistics (NCES) 2010, US Census Bureau 2010

Although most of the schools fit tightly along the line, a few schools deviated slightly more than the others in terms of the racial/ethnic composition of the zones compared to the schools. The alternate view of the same scatterplot and table showing the rates of white children in the zones compared to the white composition of the corresponding schools (Figure 13).

Figure 13: Percentage White in Zones and Percentage White in the Schools

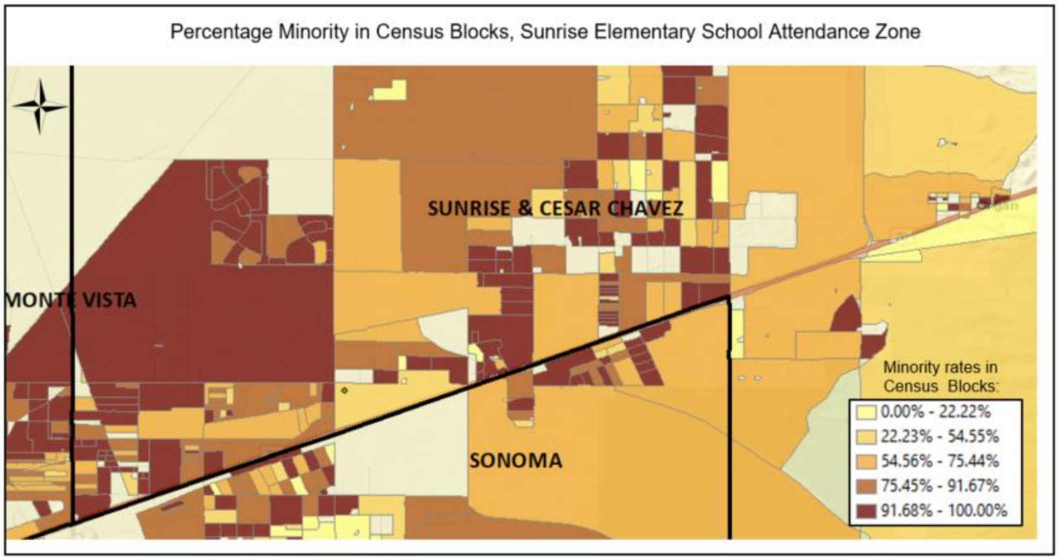


Source: National Center for Educational Statistics (NCES) 2010, US Census Bureau 2010

Several schools deviate slightly more than the other schools, as seen in schools farther away from the regression line on the scatterplot and in Figure 14 and the schools with the largest percentage difference in the upper and lower portions of Table 12. It is interesting to note that three schools at the extremes of the chart, Sunrise, Sonoma, and Highland are all located on the same side of town within reasonable distance of each other. Sunrise Elementary has the 6th lowest academic proficiency rates in the district, nearly all students qualify for free and reduced priced lunches, and the school has a higher than average number of minorities. This school also has a lower percentage of white students attending the school than there are in the zone suggesting some of the white children in that zone are either attending private schools or they are attending other schools in the district. The two schools that are located fairly close to Sunrise Elementary; Highland Elementary and Sonoma Elementary, have higher rates of white students in the schools than there are in there are in the neighborhoods. This may suggest white parents living in the Sunrise catchment zone are transporting their children to Highland and Sonoma which have lower rates of poverty, fewer minorities and are academically higher performing schools but are still geographically accessible.

A detailed look at the minority rates in blocks within Sunrise Elementary school attendance zone shows many blocks with high rates of Hispanic-Latinos next to high rates of white, non-Hispanics (Figure 14).

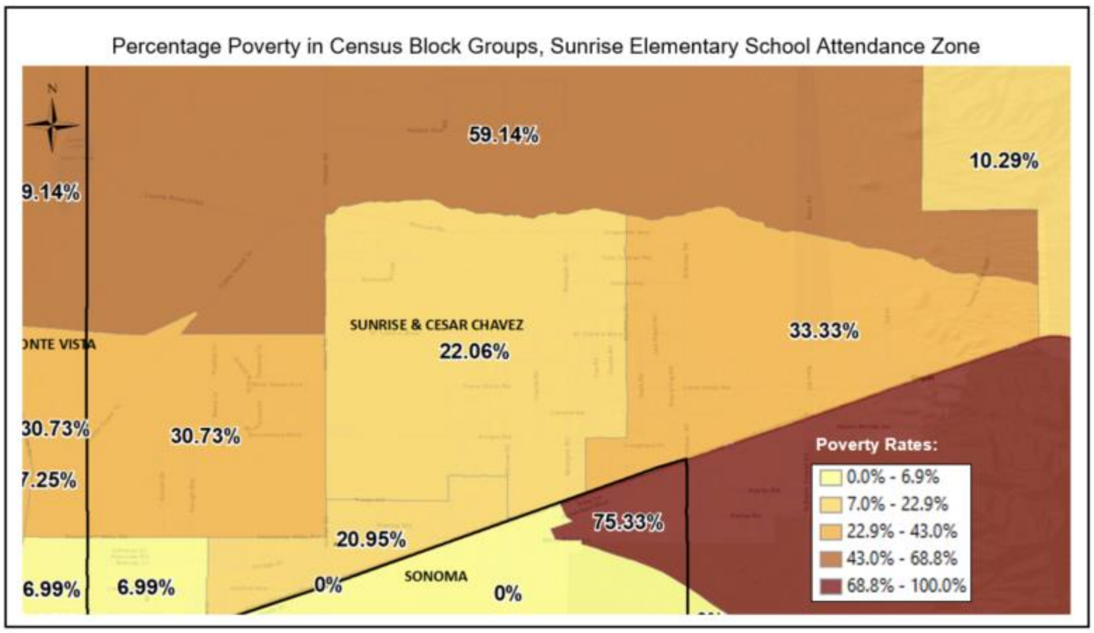
Figure 14: Detail: Minority Rates in Blocks, Sunrise Elementary School Attendance Zone



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Saporito and Sahoni's research (2007) found a relationship between high numbers of minorities in a neighborhood and fewer white students in a school. However, other research has identified poverty as a higher predictor of white flight if the minorities are Hispanic or Latino (Wahl, et al. 2006). Although it was not possible to match poverty rates in the zones compared to those in the schools because of the differences in measurement, patterns of poverty across school attendance zones offer some insight regarding the differences between minorities in the catchment zones compared to the school. Figure 15 shows a map of poverty rates in block groups inside the zones. In this map, we can see variability in the values in the Sunrise attendance zone, with a mixture of residents living in poverty, as well as, neighborhoods with low rates of poverty. Part of the variability in this zone is attributed to the rapid growth of new housing developments over the past ten years as well as the size of zone. This catchment area includes a wide variety of neighborhoods so it is plausible some students living in the Sunrise zone are attending Highland and Sonoma Elementary schools, located just down the road from Sunrise. Both of these school zones have much lower poverty rates than Sunrise.

Figure 15: Detail: Poverty Rates in Block Groups Sunrise Elementary School Attendance Zone



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Likewise, the catchment zone of Doña Ana Elementary which has the highest difference in whites in the catchment zone compared to its school, is similarly socioeconomically diverse with a mixture of newer housing developments and lower-income housing as indicated by the hot and cold spot analysis later in the study.

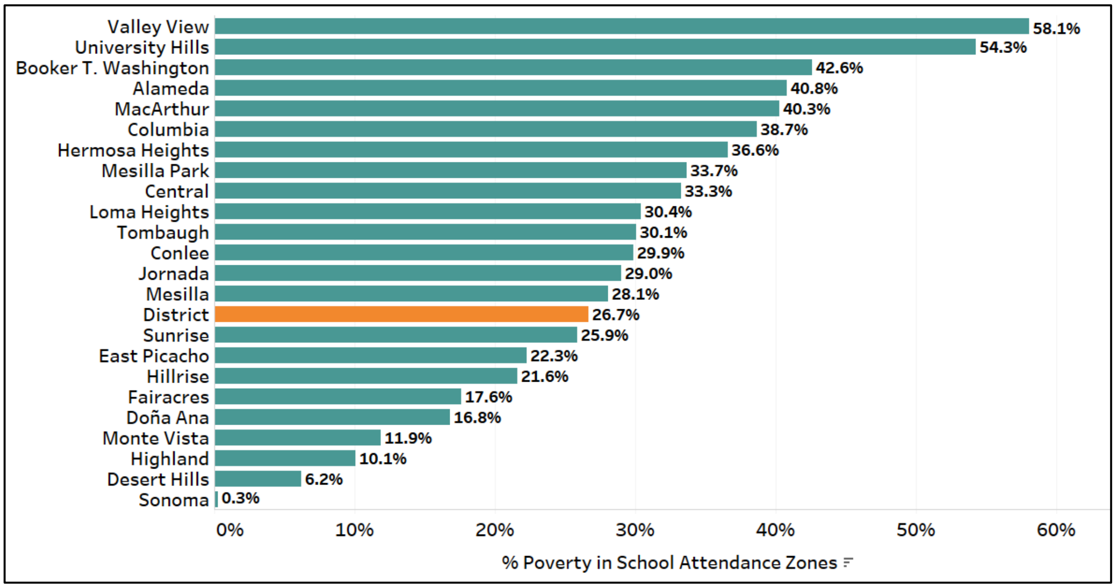
Although I cannot say for certain this is what is happening in this case, as mentioned earlier, previous research suggests white (and/or affluent) parents living in socioeconomically diverse neighborhoods assigned to low performing schools, pull their children from high minority/high poverty schools and enroll them in more affluent, higher performing schools with fewer minorities (Saporito and Sohoni 2007).

Ultimately, the initial correlation analysis showed a strong and significant relationship between the percentage of minority in schools and the percentage of minority in the zones. This indicates most minority students at LCPS are attending their assigned school. This aligns with national trends; most students attend the school they are geographically assigned to, unless there are large number of alternative school options such as charter or private schools.

8.4 Assessing the degree to which elementary school attendance zones and schools in Las Cruces Public School District are segregated.

The first step was calculating the data, percentage poverty and percentage minority, within each catchment zone and within the geographic area of the entire school district. As stated earlier, results found the poverty average for the entire district was nearly 27 percent with a range in values from 58 percent to .3 percent and a standard deviation of .14 (Figure 16).

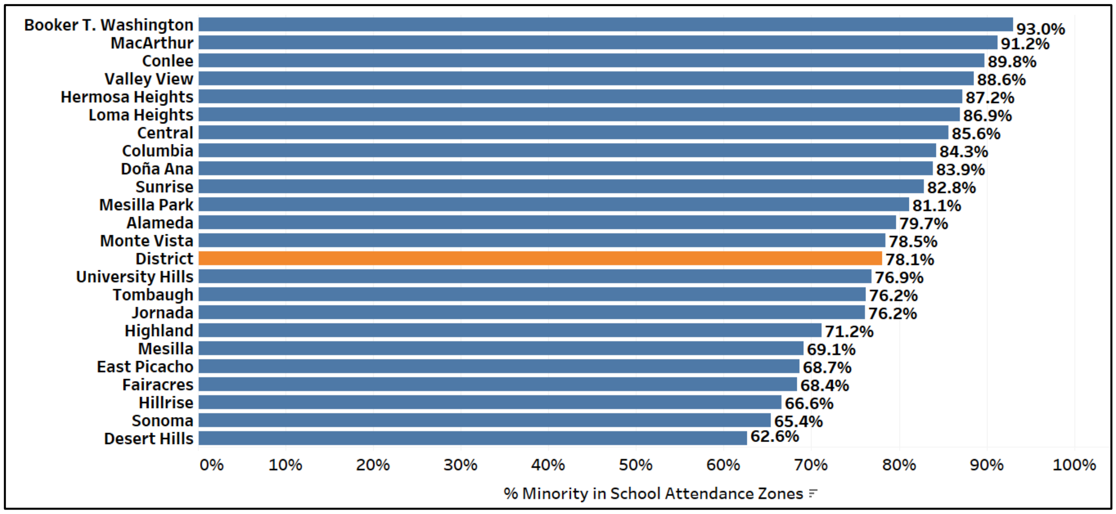
Figure 16: Percentage Poverty in School Attendance Zones



Source: US Census Bureau (2010-2014)

The graph illustrates the highest poverty rate is at Valley View Elementary and other schools more centrally located in the district while Sonoma, Desert Hills, and Highland have much lower poverty rates. The range (58%) is quite large indicating poverty is very highly concentrated in some schools compared to others. The minority average for the entire district (in orange) was 78 percent with a range in values from 93 percent to 63 percent (Figure 17).

Figure 17: Percentage Minority in School Attendanze Zones



Source: US Census Bureau (2010-2014)

The school with the largest proportion of minorities compared to the district is Booker T. Washington Elementary. The schools near the center of the chart, University Hills and Monte Vista have racial/ethnic proportions most similar to the overall district. The range (30%) is not as extreme compared to poverty rates indicating less variability and a lesser likelihood of segregation. This is not too surprising considering the vast majority of students are Hispanic/Latino.

To measure the diversity between school catchment zones relative to the overall diversity of the district, I used Theil's entropy index of segregation (also referred to as "H" or the "spatial information theory index") as well as the Dissimilarity Index. Theil's Index is often used to measure the sum of between and within group segregation and is considered superior to other segregation measures since it obeys the rule of transfers, and is considered very accurate (Iceland 2002, 2004; Reardon and Firebaugh 2002). However, the values are not as intuitive as the commonly used Dissimilarity Index (D), so this index was included in the analysis as well.

The Theil index quantifies how evenly students are distributed according to indicators such as race/ethnicity or poverty status, across schools (units) in a district and is a common measure used by scholars (Bischoff 2008; Lee, et al. 2008; Richards 2014; Owens 2016). The Theil index also has the advantage of using the weight of the population in each school attendance zone to measure segregation. This index measures the weighted average deviation of each geographic unit (school attendance zone) from the diversity of the entire school district.

There are two steps needed to create the Theil index. The first creates the diversity measure, the entropy score, which is then used to calculate the entropy index, the measurement of the distribution of groups across a school attendance zone (Forest 2005).

The entropy score consists of:

$$E = \sum_{i=1}^{r} (p_i) ln \left(\frac{1}{p_i} \right)$$

r = the number of racial/ethnic groups in the population (in this case 2) and p_i = each groups proportion of the school catchment zone or district population as a whole.

The entropy score for the entire district resulted in E= 0.525. Next, Theil's index was calculated as a weighted average deviation in the entropy between each school catchment zone and the district as a whole:

$$H = \sum_{i=1}^{n} \left[\frac{t_i (E - E_i)}{ET} \right]$$

- n= number of school zones in a district
- t_i = total population of school zone i,
- T= total school district population
- E_i= entropy of the school zone
- E= entropy of the entire district

Like most indices, the Theil index ranges between 0 and 1. In this study, 0 indicates a school attendance zone has the same racial/ethnic or poverty composition as the overall district while 1 indicates a school catchment zone contains students of a single ethnic/racial group or poverty status (maximum segregation). The Theil H Index resulted in a value of 0.093 for poverty rates and 0.044 for minority rates across the district. This can be interpreted to mean that the average school attendance zone is 9 percent less diverse (regarding poverty rates) than the entire school district and 4 percent less racially/ethnically diverse than the entire school district (Bischoff 2008; Lee, et al. 2008).

Although there is no numeric threshold attached to the H Index, on the surface, there do not seem to be high levels of segregation. However, H indices can vary considerably and are best interpreted within the context of a study. The size of the units for analysis and the variables used for analysis, need to be considered. For example, according to one study, black–white racial segregation in most American cities generates H values of 0.4 to 0.5 and a D value of 0.7 (the H index is typically much lower than other measures such as the Dissimilarity Index) (Quillan 2014). However, segregation research routinely identifies Black-White segregation in the United States as more extreme than White-Hispanic segregation (Bischoff 2008). In studies comparing school districts, H values are much lower. Bischoff's study comparing school district segregation and fragmentation across 304 metropolitan statistical areas (MSAs) resulted in an average Black-White H index of 0.12 and a Hispanic- White H index of 0.07 (Bischoff, 196). In this context, the H index in this study (0.04) is slightly lower and thus, shows less segregation by race and ethnicity. The H index for income segregation across Las Cruces Public School District (0.09) was comparable to income segregation between 95 of the largest school districts, which generates an H index of 0.088.

It is also important to keep in mind that the H index is sensitive to both scale and the number of units being analyzed. The larger the geographic scale, the lower the H index. For example, a person is more likely to encounter people of different races, the larger the area they are interacting in. In one study, researchers found the average Hispanic-White H index in 100 metro areas was 0.282 within a 500m radius of their home compared to 0.154 within a 4,000m radius of their home (Lee, et al. 2008). Typically, the smaller the scale, the higher the level of segregation. In addition, there is a difference in the magnitude of the H index when examining racial segregation compared to income segregation. For example, in 2010 the average between district income segregation among families with children enrolled in public schools within 95 of the largest metropolitan areas was .089 whereas it was 0.16 among Hispanic and white Non-Hispanics[7] (Owens, Reardon and Jencks 2016). Within this context, it is not surprising the H values were small for this study which included not only several large school attendance zones, but also a population where the statistical majority are minorities. In addition, the H index is typically used to observe segregation trends over time, not as a stand-alone value in a study which make the value not as intuitive to interpret. The Dissimilarity Index (D) is another index that is often used to measure segregation. I estimated the D index across school attendance zones and the schools as an alternate measure of segregation. The Dissimilarity Index is the most widely used (and perhaps most widely understood) evenness measure (Census 2016).

[7] The researchers found the average between school income segregation was between .21 to .23 between 1991 and 2012.

The Dissimilarity Index estimates the degree to which different groups are distributed evenly across units in a metropolitan area; in this case, attendance zones in a school district. If two groups are distributed evenly, each school attendance zone will have the same racial/ethnic balance (and poverty balance) as the overall school district. The Dissimilarity Index also ranges from 0.0 (all areas have the same composition as the school district) to 1.0 (complete segregation, zones that include people from only one group). The formula for the D Index is:

$$D = \left(\frac{1}{2}\right)\sum_{i=1}^{N}\left(\frac{M_i}{M} - \frac{W_i}{W}\right)$$

Where:

M_i = the minority population in school i
M = the minority population in the district
W_i = the white non-Hispanic population in school i
W = the white non-Hispanic population in the district

D represents the percentage of a group's population that would have to switch to other school attendance zones for every school attendance zone to reflect the same racial/ethnic or economic composition of the overall school district. The D index for minorities across Las Cruces Public school attendance zones was .22, meaning that 22 percent of minority students (or whites) would need to switch schools for all zones to have the same racial composition. This result was very similar to the D index (.276 for Hispanic and white Non-Hispanic) found in a previous study examining segregation across 15,290 school districts (Richards 2014). Likewise, I calculated the Dissimilarity Index between children living below the poverty line and those not living below the poverty line in the school attendance zones. The segregation index for poverty was .27, meaning 27 percent of students in the district would need to switch zones for there to be an even distribution of economically disadvantaged students across the district. Table 12 illustrates the H indices and the D indices for school attendance zones (SAZs).

Table 12: H Indices and Dissimilarity Indices for Minority and Poverty in School Attendance Zones

H Index SAZs (Minority)	H Index SAZs (Poverty)	D Index SAZ (Minority)	D Index SAZ (Poverty)
0.044	0.093	0.22	0.27

Although this level of segregation may not be as high as seen in major cities, it is comparable to those found in school attendance zone research. These indices tell us that approximately one quarter of students would need to change school catchment zones for the zones to reflect the socioeconomic composition of the district. This is worth noting considering the relationship between high poverty/high minority schools and low academic achievement.

School level results revealed a higher degree of segregation between schools with high poverty rates and those without. This was not surprising since the poverty measurement at school level (free and reduced-price lunch status) captures more poverty since it includes children up to 185 percent of the poverty level[8]. There was an increase in the H index for poverty in the schools (0.183) compared to the zones (0.093). There was a slight increase in the H index for minorities in the schools (0.064) compared to the zones (0.044). A dissimilarity index of 0.45 in the schools, indicated 45 percent of students would need to move to other schools for the poverty rates in each elementary school to reflect the poverty rate of the entire school district. This is a larger degree of segregation compared to Saporito and Sahoni's study (2007) which found the average D index for income segregation in schools within 21 of the largest school districts in the country, was 39.1 percent and 34.7 percent in the school attendance zones. Minorities in Las Cruces were comparatively less segregated with a dissimilarity index of 0.28. In other words, 28 percent of minorities would need to switch schools for each school to mirror the racial and ethnic composition of the district. These results are illustrated in table 13.

[8] In addition, in some high poverty schools, if the school has minimum of 85% of students qualifying for FRPL, all students receive FRPL regardless of income.

Table 13: H Indices and Dissimilarity Indices for Minority and Poverty in Schools

H Index Schools (Minority)	H Index Schools (Poverty)	D Index Schools (Minority)	D Index Schools (Poverty)
0.064	0.183	0.28	0.45

In conclusion, the D index for poverty in LCPS school attendance zones is approximately 8 percentage points lower than the mean dissimilarity index in a large school districts (Saporito and Sohoni 2007). However, it should be kept in mind, the measurement in Saporito and Sahoni's study used a different geographic measurement. Their measurement included residents up to 130 percent of the FPL whereas this study only included those under 100 percent of the FPL. In addition, the H index in LCPS school attendance zones mirror similar patterns found in segregation research conducted in larger school districts.

Comparing the mean dissimilarity index for poverty at the school level results in a dissimilarity index 6 percentage points higher in LCPS compared to the mean dissimilarity index in larger districts. In other words, LCPS elementary students are more segregated on average than students in larger school districts. In addition, it appears students attending LCPS are more segregated by income than by race or ethnicity. This is more apparent at the school level, especially for poverty rates, due to the differences in measurement. However, the fact that there is nearly a 60 percent difference in poverty rates between the zone with the highest rate of poverty in LCPS and the zone with the lowest rate of poverty, indicates there is an uneven distribution of students across schools. This should be taken into consideration as the school district grows.

8.5 Determine if academic performance is a function of the socioeconomic composition of the school and school attendance zone.

Descriptive statistics earlier in the study identified a strong and significant relationship ($r = .86$) between poverty rates and minority rates in the schools. Considering this, I conducted a multiple regression that checked for multicollinearity, along with two simple linear regressions. Minority rates and poverty rates in the schools were the independent variables and academic proficiency was the dependent variable. Initial results did not show a significant relationship between the percentage minority in a school and academic performance, nor the percentage poverty in the schools and academic performance (Table 14).

Table 14: Multiple and Simple Linear Regression Models; Model 1- multiple regression (minority rates/poverty rates in schools and proficiency rates), Model 2- minority rates and proficiency rates, Model 3- poverty rates in schools and proficiency rates, Grades K-3rd

	Model 1			Model 2			Model 3		
Variables	*b*	*SE b*	*p*	*b*	*SE b*	*p*	*b*	*SE b*	*p*
% Minority	-0.403	0.281	0.167	*-0.847*	*0.152*	*0.000*			
% Poverty	-0.252	0.138	0.082				-0.422	0.072	0.000
Constant	1.037	0.151		1.208	0.125		0.836	0.057	
Adjusted R^2	0.621								
R^2	0.656			0.598			0.62		

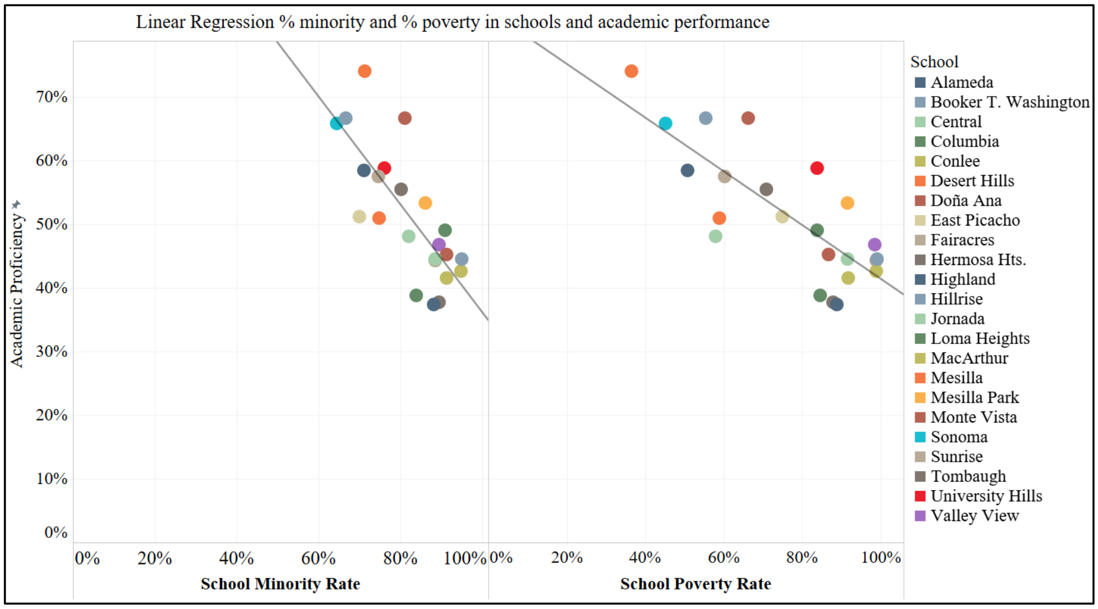
N= 23 VIF= 3.831 Tolerance= .261

However, if two or more independent variables are highly related they will inflate the coefficients and significance levels, because it is essentially like using the same variable twice. The tolerance factor and variance inflation factor (VIF) were checked to identify multicollinearity in the regression analysis. The tolerance statistic is $1 – R^2$, in other words, 1 minus the amount of variance in the independent variable explained by all other independent variables. The tolerance was .261, which means approximately 74 percent of the variance of one independent variable is shared with the other independent variable. Low tolerance factors (below .20) indicate multicollinearity (De Mars 2017). Although this factor is slightly above, it suggests a redundancy in the variables.

The VIF statistic, the inverse of the tolerance factor, provides an index that measures how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of collinearity (Allison 2012). A VIF statistic is always greater than, or equal to, 1 (Consultation 2007). The VIF statistic was 3.831 meaning the standard error for the coefficient of the predictor variable is approximately 3.8 times as large as it would be if that predictor variable was uncorrelated with the other predictor variables. Although there is no specific threshold for a VIF statistic, a VIF below 5 typically does not suggest multicollinearity, unless it is observed in a weaker model, where a VIF above 2.5 may indicate collinearity (Consultation 2007). This model could be considered a “weak” model since there are only 23 cases. The adjusted R^2 was .62. R^2 tells us the amount of variability in the dependent variable that is explained by the independent variables. The coefficient of determinations demonstrated that nearly 62 percent of the variability in academic proficiency is accounted for by minority and poverty rates in the schools.

It is possible the correlation between the two independent variables and the low sample size, resulted in both variables competing to explain the relationship to proficiency and caused both variables to lose any effect on the dependent variable. Considering this, the independent variables were separately regressed with academic proficiency in the schools (Figure 18). The results were significant (see table 15) and illustrate that for every percentage increase in minority rates, academic achievement decreases -0.847 percent. Likewise, for every percentage point increase in poverty rates, academic achievement decreases -0.421 percent.

Figure 18: Linear Regression Scatterplots: Elementary School Poverty Rates, Minority Rates and Proficiency Rates, Grades K-3rd.



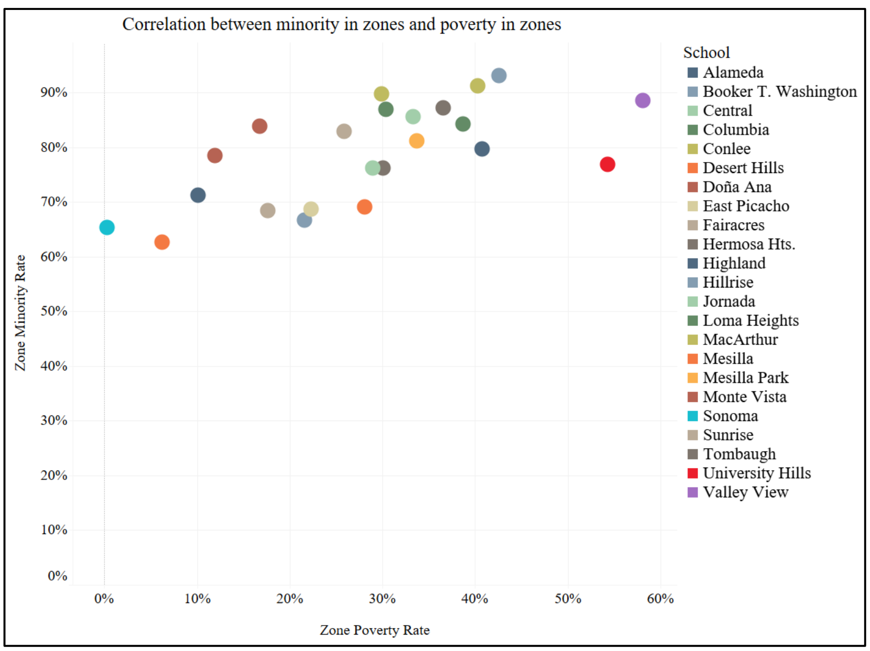
To determine if academic performance was a function of the socioeconomic composition of the school attendance zone, the relationship between pairs of data (catchment zone composition and academic performance) were measured with linear regressions and geographically weighted regressions. First, I conducted a Pearson's Correlation analysis between poverty rates in the school attendance zones and minority rates in the zones to determine the strength of their relationship to each other. The results found the poverty rates in zones were moderately related to minority rates in zones; r = 0.656, p < 0.0001 (Table 15, Figure 19).

Table 15: Correlation: Percentage Minority in Zones and Percentage Poverty in Zones

	% Poverty in Zones	% Minority in Zones
% Poverty in Zones	1	-0.656
% Minority in Zones	0.656***	1

***p< 0.001

Figure 19: Pearson's Correlation, Minority and Poverty Rates in SAZs



Next, I conducted several regression analyses between the characteristics in the school attendance zones as related to academic proficiency in the schools. First, a multiple regression analysis using percentage minority in the zones and percentage in poverty in the zones as independent variables, and academic performance (school proficiency) as the dependent variable, was conducted. The linear regression model for the minority and poverty rates as related to academic performance is $y = x^1 * -.719 + x^2 *- .136 + 1.119$, where x^1= the percentage minority in the school attendance zones and x^2 = the percentage in poverty in the school attendance zones. Results showed a negative relationship between the socioeconomic composition of the zones and the proficiency rates in schools (Table 16). The R^2 of 0.60 indicated that 60 percent of the variation in the dependent variable academic proficiency is explained by the independent variables. However, only the variable minority was significant with a p value of $< .001$.

Table 16: Regression Models, Minority and Poverty in SAZs and Academic Proficiency: Multiple Regression, and Two Simple Regression Models

	Model 1			Model 2			Model 3		
Variables	b	SE b	p	b	SE b	p	b	SE b	p
% Minority	-0.720	0.209	0.003	-0.862	0.158	0.000			
% Poverty	-0.137	0.132	0.312				-0.435	0.123	0.002
Constant	1.119	0.143		1.192	0.125		0.637	0.039	
R^2	0.608			0.587			0.375		

N= 23 VIF= 1.755 Tolerance= .57

The coefficients tell us, when controlling for poverty, for every one percentage increase of minority in a zone, proficiency will decrease -0.72 percent.

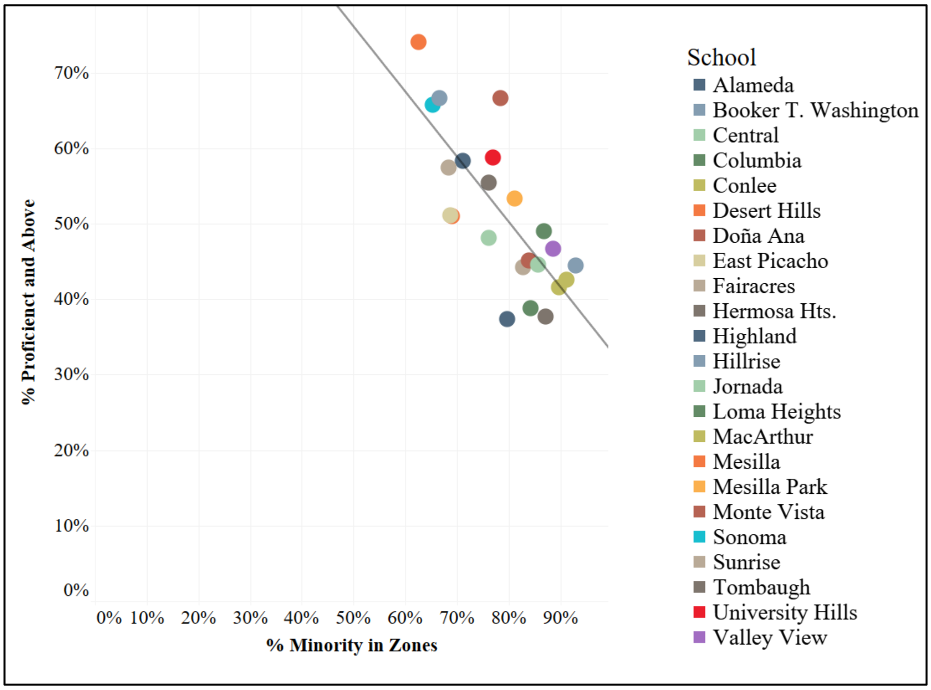
This is significant with a p value of $< .01$. Examining the p value for percentage poverty in the zone was not significant at $p = 0.31$. The model indicates that minority rates in the zones are related to academic proficiency rates when controlling for poverty but not the other way around.

Considering the strong correlation between minority status and poverty in the schools, multicollinearity tests checked for redundancy in the variables. The tolerance factor was .57, which means that 43 percent of the variance of one independent variable is shared with other independent variables. Low tolerance factors (below .20) indicate multicollinearity, so this factor does not suggest multicollinearity (De Mars 2017).

As stated earlier, the VIF statistic, the inverse of the tolerance factor, provides an index that measures how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of collinearity (Allison 2012). A VIF statistic is always greater than, or equal to, 1 (Consultation 2007). The VIF statistic was 1.755 meaning the standard error for the coefficient of the predictor variable is approximately 1.755 times as large as it would be if that predictor variable was uncorrelated with the other predictor variables. Although there is no specific threshold for a VIF statistic, a VIF this low does not suggest multicollinearity. Considering the tolerance factor, multicollinearity should not be a major concern. However, we should still bear in mind the possible multicollinearity between the two independent variables at school level and the limitations of the poverty measure at geographic level. In consideration of this, the independent variables were independently regressed with academic proficiency in the schools.

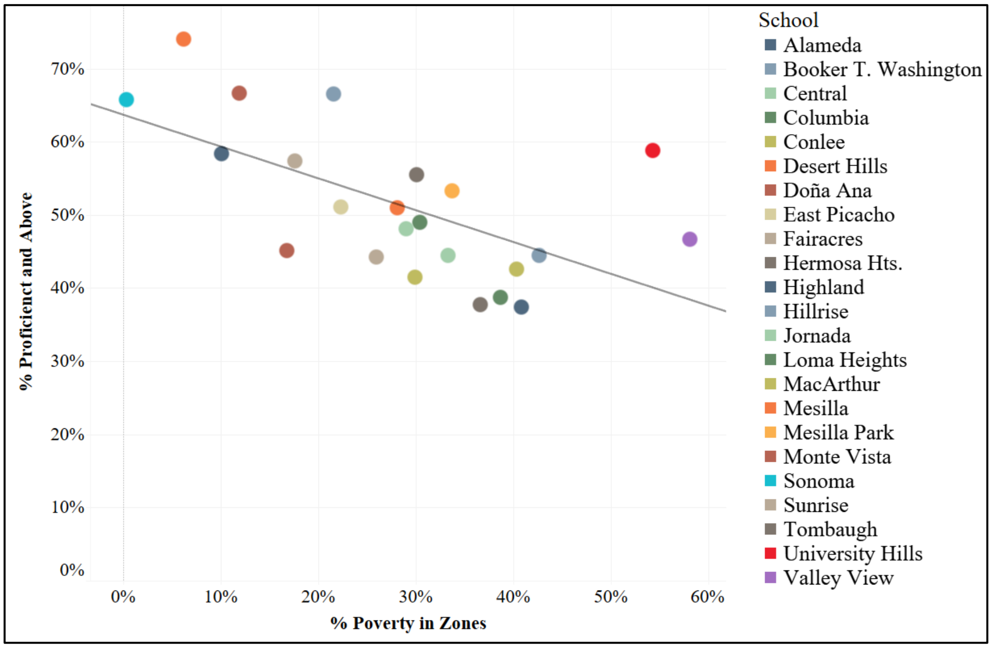
For the linear regression and geographically weighted regression analysis, percentage minority in the zone was the independent variable and academic performance (school proficiency) was the dependent variable. The linear regression model for the minority rates, as related to academic performance, is y= -0.862 * x + 1.1922, where x= the percentage minority in a school attendance zone. Results showed a strong negative relationship between percentage minority in a zone and the proficiency rates in schools. A R^2 of .59 indicates 59 percent of variance in proficiency is explained by the percentage minority in a school attendance zone and for each percentage increase in minority in a zone, academic proficiency decreases -0.86. This is significant with a p value equal to .000 (Figure 20).

Figure 20: Linear Regression: Academic Proficiency as a Function of Minority in SAZs



Next, I conducted a linear regression analysis using percentage poverty in the zones as an independent variable and academic performance (school proficiency) as the dependent variable. The linear regression model for the poverty rates as related to academic performance is y= -0.435 * x + 0.6371, where x= the percentage poverty in a school attendance zone. Results showed a negative relationship between percentage poverty in a zone and the proficiency rates in schools. An R^2 of .37 indicated 37 percent of variance in proficiency was explained by the percentage poverty in a school attendance zone. In addition, for each percent increase in poverty in a zone, academic proficiency decreased -0.435. This is significant with a p value of $< .0001$ (Figure 21).

Figure 21: Linear Regression: Academic Proficiency as a Function of Poverty in SAZs



However, the scatterplot in Figure 21 indicates University Hills Elementary as a possible outlier. This was checked against an analysis of the residuals (the observed value less the predicted values). The scatterplot in Figure 22 and Table 17 illustrate University Hills Elementary with a .18 residual value.

Figure 22: Standardized Residuals, Poverty in SAZs and Proficiency Regression Analysis

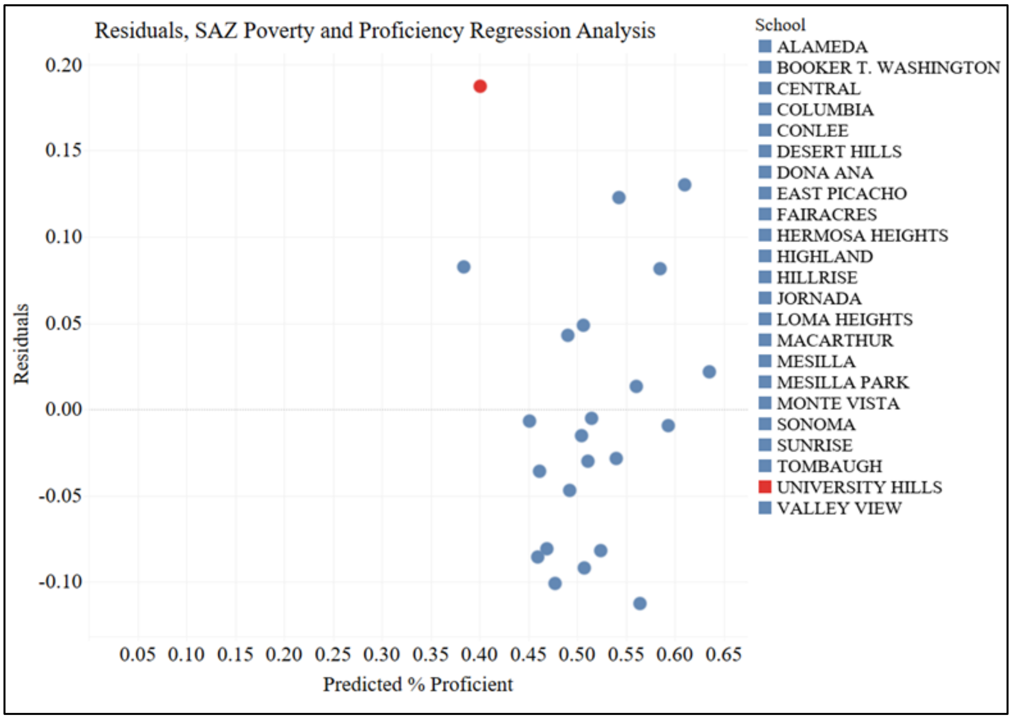


Table 17: Standardized Residuals, Poverty in SAZs and Proficiency Regression Analysis

School	Predicted % Proficient	Residuals y
UNIVERSITY HILLS	0.4007	0.1873
DESERT HILLS	0.6101	0.1301
HILLRISE	0.5430	0.1227
VALLEY VIEW	0.3841	0.0828
MONTE VISTA	0.5853	0.0814
TOMBAUGH	0.5060	0.0486
MESILLA PARK	0.4904	0.0428
SONOMA	0.6358	0.0217
FAIRACRES	0.5605	0.0136
MESILLA	0.5147	-0.0053
BOOKER T. WASHINGTON	0.4516	-0.0066
HIGHLAND	0.5931	-0.0095
LOMA HEIGHTS	0.5047	-0.0152
EAST PICACHO	0.5400	-0.0286
JORNADA	0.5108	-0.0298
MACARTHUR	0.4616	-0.0358
CENTRAL	0.4921	-0.0470
COLUMBIA	0.4686	-0.0809
SUNRISE	0.5243	-0.0820
ALAMEDA	0.4594	-0.0854
CONLEE	0.5069	-0.0916
HERMOSA HEIGHTS	0.4777	-0.1009
DONA ANA	0.5639	-0.1125

Considering this possible outlier, I reran the regression analysis (percentage poverty as the predictor variable) with University Hills removed. The results indicated a R^2 of .55 which indicated that 55 percent of the variance in proficiency was explained by the percentage poverty in a school attendance zone. In addition, for each unit increase in poverty in a zone, academic proficiency decreases -0.566. This was significant with a p value of $< .0001$.

Hence, removing the outlier from the linear regression model resulted in an 18 percent increase in influence that can be attributed to poverty and the R^2 equaled .522, a statistic much closer to the R^2 of .586 for minority rates in the zones. This is not surprising since the correlation between school level poverty rates and minority rates was high (r = .86).

It is plausible that the location of University Hills, near New Mexico State University, in a neighborhood that likely includes many university student families, may be related to higher proficiency scores in the school. It is a well-known that academic proficiency in children is highly correlated with the education levels of their parents. Children with college educated parents typically have higher academic proficiency rates than children raised by non-college educated parents. Of course, there may be another school related factor such as teaching staff /administration or an academic intervention helping this particular school overcome the predictive patterns between the socioeconomic composition of a school and academic performance.

Rerunning the multiple regression another time with University Hills removed resulted in an adjusted R^2 of .626 meaning nearly 63 percent of proficiency rates are explained by the independent variables in the zones (Table 18). In addition, when controlling for poverty, for each percentage increase in minority in a zone, academic proficiency decreases -0.539. This was significant with a p value of .02. When controlling for minority, for each percentage increase in poverty in a zone, academic proficiency decreases -0.295. The p value for poverty was .06, slightly over the recommended alpha of 0.05. These results indicate proficiency is primarily explained by race/ethnicity in a school attendance zone and poverty to a much lesser degree.

Table 3: Multiple Regression Analysis, Poverty and Minority Rates in SAZs and Proficiency Rates with University Hills Removed

	Academic Proficiency		
Variables	*b*	*SE b*	*p*
% Minority	-0.539	0.218	0.023
% Poverty	-0.295	0.15	0.063
Constant	1.016	0.146	
Adjusted R^2	0.626		
R^2	0.661		

N= 22 VIF= 2.164, Tolerence= .462

Spatial analyses conducted in ArcGIS software further confirmed the aspatial analyses. First, I conducted ordinary least squares regression using percentage minority and percentage poverty as predictor variables and academic proficiency at the school level as the dependents variable. OLS results in ArcGIS reaffirmed the results of the multiple regression analysis (Table 19). The VIF statistic was 1.755956 for both minority and poverty rates which does not suggest multicollinearity.

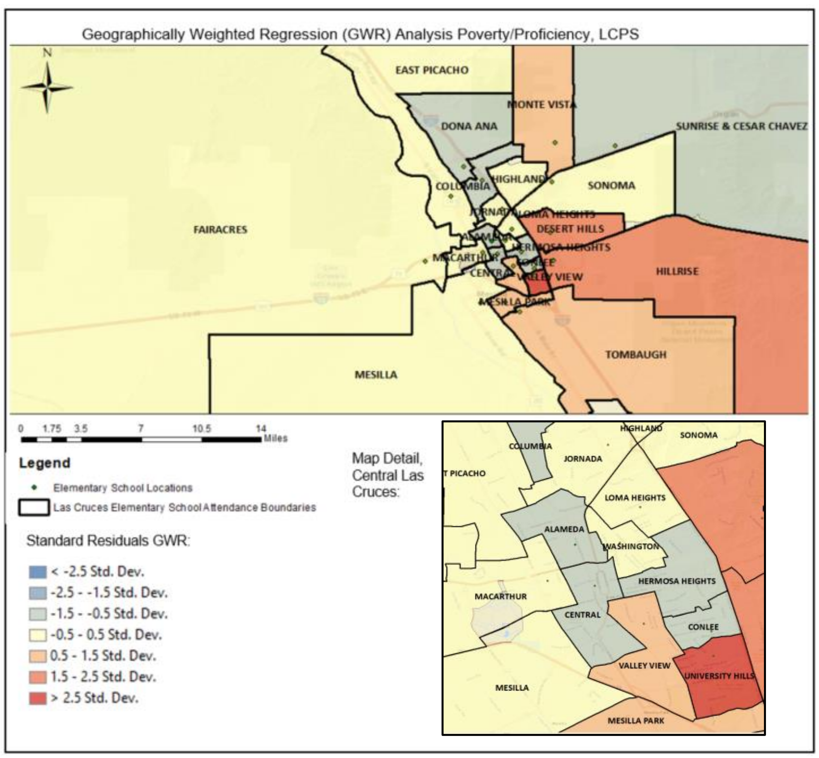
Table 19: Ordinary Least Squares Regression Analysis in ArcGIS, Poverty and Minority Rates in SAZs

	Academic Proficiency	
Predictor variables	b	SE
Minority in Zones	-0.72***	0.21
Poverty in Zones	-0.14	0.13

N=23, ***p< 0.001

However, the Jarque-Bera Statistic was statistically significant ($p < .01$) indicating the model predictions were biased (the residuals were not normally distributed). This is likely because of the poverty rates were included in the model and the outlier status of University Hills Elementary. The outlier status of University Hills was further illustrated in a geographically weighted regression (GWR) analysis using poverty as the independent variable and academic proficiency as the dependent variable (Figure 23).

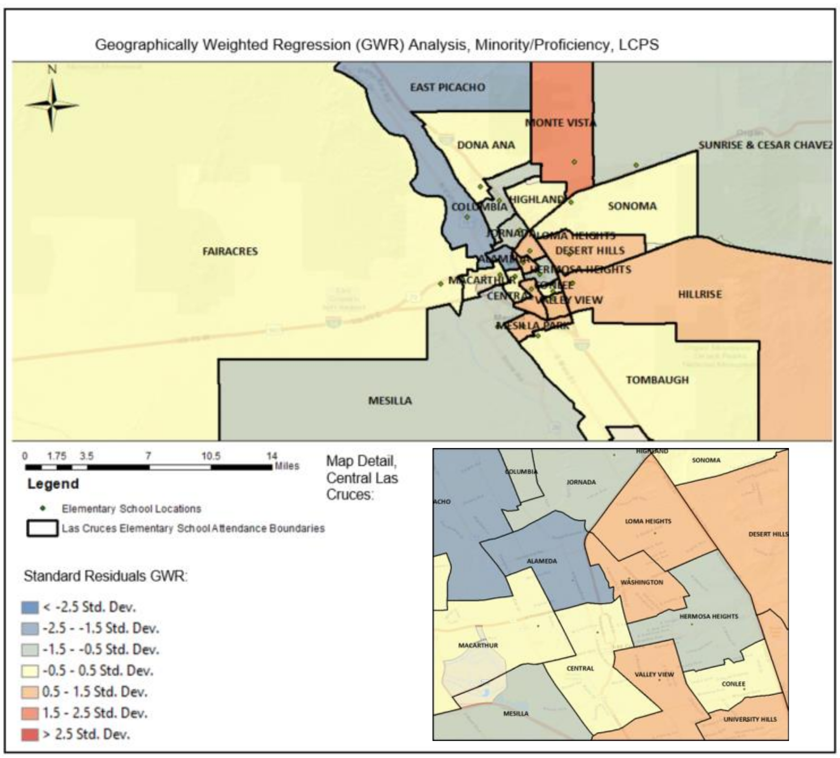
Figure 23: LCPS Map of School Attendance Zones and GWR Analysis of Poverty and Academic Proficiency Rates with Standardized Residuals



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Again, the standard residuals resulted in more than 2. 5 standard deviations for the percent poverty in University Hills school attendance zone. A geographically weighted regression (GWR) analysis using minority rates as the predictor, independent variable and academic performance as the dependent variable showed Monte Vista with the highest standard deviation meaning that their academic proficiency deviates more than one would expect given the demographics of that zone (Figure 24).

Figure 24: LCPS Map of School Attendance Zones and GWR Analysis of Minority and Academic Proficiency Rates with Standardized Residuals



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Both maps can be interpreted to mean that redder zones have higher proficiency rates than would be expected given the percentage in poverty or the percentage minority in the zone while the bluer areas have a lower proficiency rate than would be expected given the demographics. It is important to note, three schools with higher proficiency than expected Monte Vista, Hillrise, and Desert Hills are all schools with lower than average rates of poverty and minorities while schools with lower than expected proficiency rates are schools with higher than average minority and poverty rates such as Sunrise and East Picacho elementary schools.

8.6 Determine if the socioeconomic composition of a neighborhood predicts its inclusion into a high or low performing school.

First, I conducted an area pattern analyses of the blocks and block groups to examine spatial autocorrelation. This gave an indication of patterns along adjoining boundaries to determine where to conduct a GWR analysis along school attendance boundaries that possibly divide students of different socioeconomic backgrounds. There are two types of tools that test for analyzing spatial patterns like spatial autocorrelation and high-low clustering; global and local (McGrew, Lembo and Monroe 2014). Global tests examine the existence of overall clustering over the overall study area to identify if there is a correlation between values. Global tools do not identify where they are located nor do they identify the type of clustering happening (high or low), just whether clustering exists. Local tools on the other hand, identify local clusters, which are the relation between a feature's attribute values and the attribute values of its neighbors. Local tools map out the clusters, so an analyst can identify where the correlations are located and the type of clustering that is happening. For example, a local hot spot analysis could identify a block group with high poverty rates, surrounded by block groups with low poverty rates.

First, I conducted Global Moran's I Analysis which locates attribute values in geographic areas that are joined, share a common edge or boundary (a neighboring pair) to determine if areas with similar values are clustered, randomly located, or dispersed across the overall study area. Essentially, Global Moran's I Index calculates the tendency of a feature and its neighbors to differ from the overall mean of the data set (in this case the entire school district). For the Global Moran's I statistic, the null hypothesis states that the attribute being analyzed (in this case percentage poverty in block groups and percentage minority in blocks) are randomly distributed across the study area. This statistic indicates if there are clusters of similar values but not whether they are composed of high or low values. If the average difference between features is less than the average among all features, then the values are considered "clustered". A positive z-score indicates clustering and a negative z-score indicates a dispersed pattern (Mitchell 2009).

Table 20 presents the results for the Global Moran's I analyses. The distribution of minorities across census blocks identified a spatial correlation with a z-score= 16.19[9] and was significant at p= <.001, indicating there is a less than 1 percent likelihood that this clustered pattern could be the result of random chance. Similarly, significant clustering of students living in poverty within block groups across the school district was identified with a z-score of 8.75, and p <.001.

Table 20: Moran's I, Percentage Minority in Census Blocks and Percent Poverty in Block Groups

Variable	**Moran's Index**	**Z**	**P-value**
Percent Minority	0.362 (-0.00526)	8.75	0.000
Percent Poverty	0.222 (-.000375)	16.19	0.000

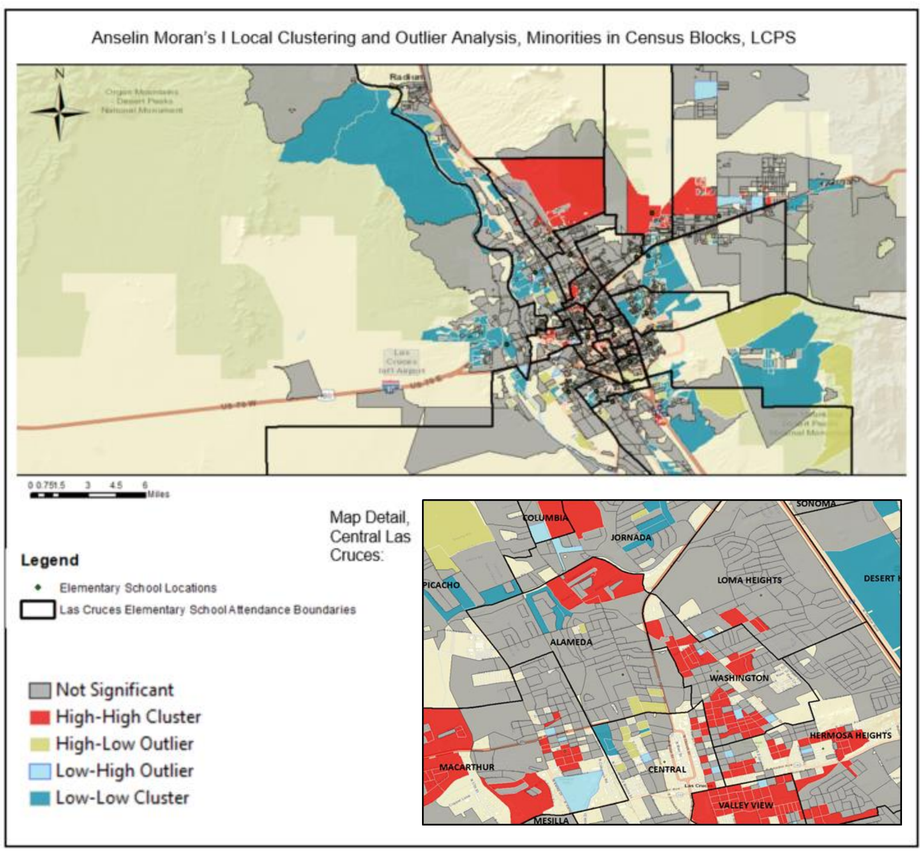
Expected value in parentheses

Since the global tool, Moran's I, identified clustering and supported my hypothesis that demographics within school attendance zones would not reflect the overall district, the next step was creating maps with the local tools to identify the location of clustering. A cluster and outlier analysis performed with Anselin Local Moran's I, identifies statistically significant hot spots, cold spots, and spatial outliers (a high value surrounded by low values or a low value surrounded by high values) when given a set of weighted features. Anselin Local Moran's I is the local equivalent of Moran's I. Figure 25 illustrates the results of the minority clustering

[9] The critical value of a z-score for Moran's I is 2.58.

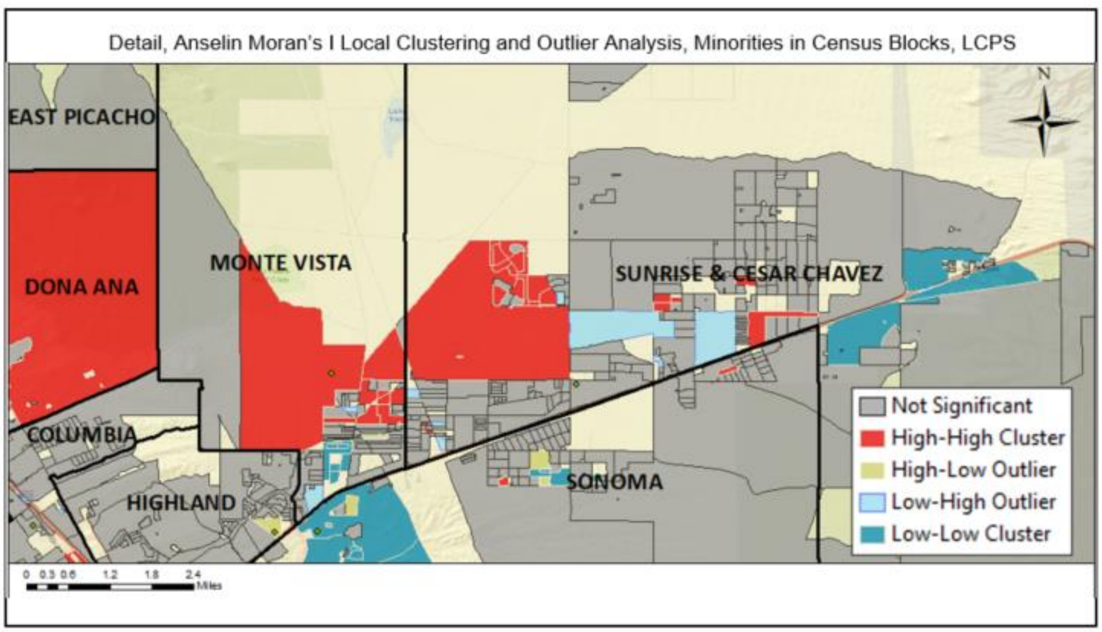
across blocks with high percentages of minorities clustered together in red while low percentages of minorities are clustered in blue. The blocks that are unlike their neighbors are indicated in yellow-green (higher percentages of minorities compared to neighbors or light blue areas indicating lower percentages of minorities compared to surrounding areas. The gray areas show no significant difference compared to its neighbors.

Figure 25: Anselin Moran's I Local Clustering and Outlier Analysis- Minorities in Census Blocks



Examining the map in closer detail (Figure 26), we can see that there are several blocks in the Sunrise Elementary catchment zone with lower than would be expected minorities. In other words, blocks with higher than expected white children surrounded by blocks with more minorities. This could support the idea that parents may be transferring their children to Sonoma Elementary with fewer minority children as indicated by the clustering of lower than expected percentages of minorities in Sonoma Elementary catchment zone.

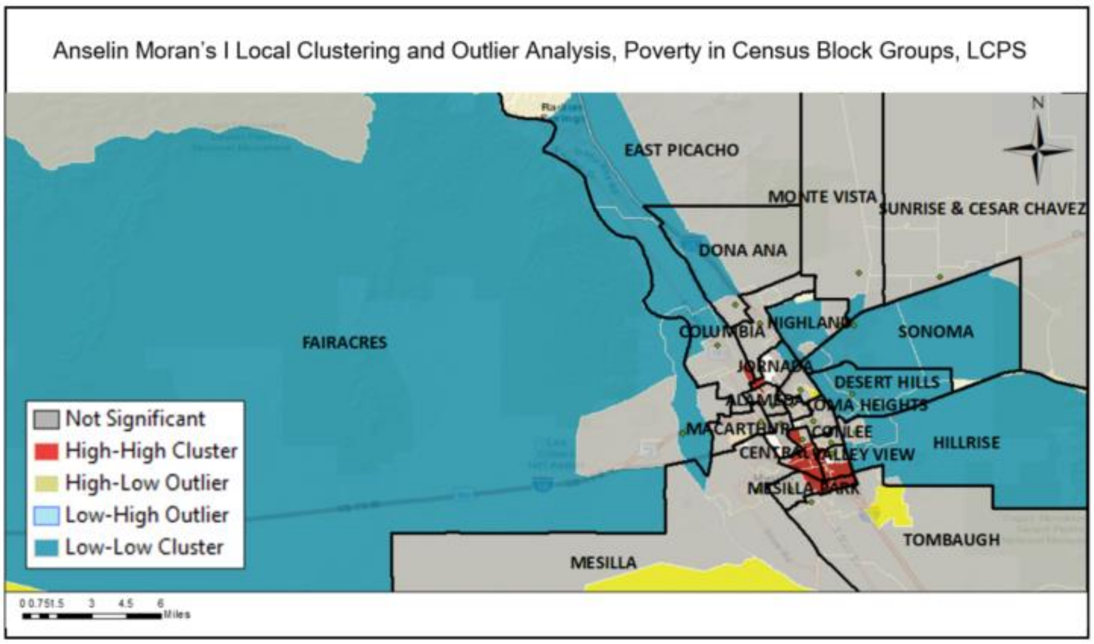
Figure 26: Map Detail, Anselin Moran's I Local Clustering and Outlier Analysis-Minorities in Census Blocks



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

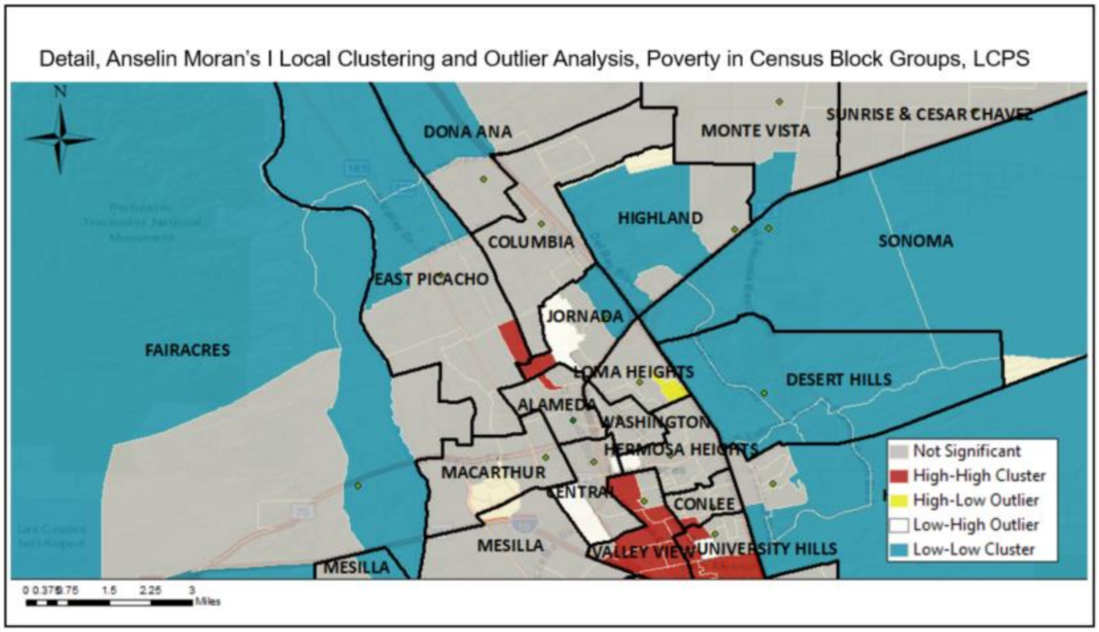
The next step was to conduct an Anselin Moran's I analysis on the poverty rates in the block groups which identified clusters of low poverty block groups in the eastern part of the map; Sonoma, Hillrise, and Desert Hills Elementary attendance zones and high clusters of poverty in the center of the map (Figures 27 and 28).

Figure 27: Anselin Moran's I Local Clustering and Outlier Analysis- Poverty in Census Block Groups



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Figure 28: Map Detail, Anselin Moran's I Local Clustering and Outlier Analysis-Poverty in Census Block Groups



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

I also computed the General G- statistic, another global tool which calculates a single statistic for the entire study area and measures the concentrations of high or low areas over the study area (the school district). The General G statistic indicates whether hot spots and cold spots are in the entire study area. Significance is indicated with a Z score, a positive z says high values are clustered and a negative z says low values are clustered. The General G analysis for minorities in blocks resulted in a z-score of 6.635, $p < .001$, indicating there is a less than 1 percent likelihood that the high-clustered pattern could be the result of random chance (Table 21). Likewise, the same analysis on the percentage poverty in block groups produced a z-score of 5.62

p< .001, indicating there is a less than 1 percent likelihood that the high-clustered pattern could be the result of random chance.

Table 21: General G High-Low Clustering Analysis Percentage Minority in Census Blocks and Percentage Poverty in Census Block Groups

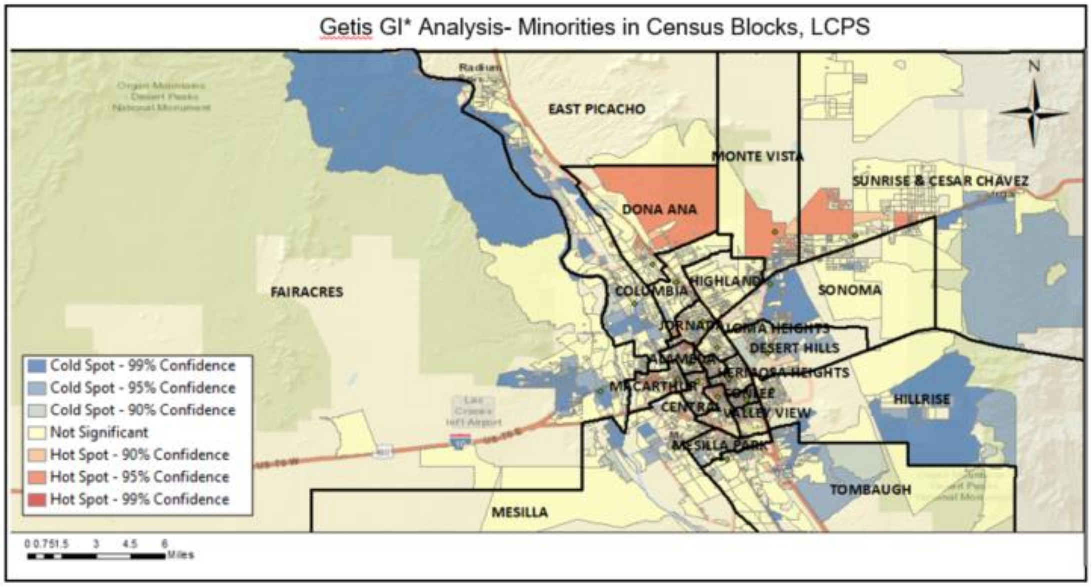
Variable	**General G**	**Z**
Percent Minority	0.000387*** (-0.00372)	6.635
Percent Poverty	0.00649*** (-0.00526)	5.623

*** p < .001, Expected value in parentheses

Since the global tools General G identified clustering, the next step was creating a map with the local tools to find where the clustering was happening and identify the hot and/or cold spots. Given a set of weighted features, hot and cold spot analyses identify statistically significant hot spots and cold spots using the Getis-Ord Gi* statistic. A hot spot analysis explores the probability that a spatial distribution of values is random. It works by evaluating each polygon's value and finding relationships with surrounding values. However, to observe patterns there must be variations in the values.

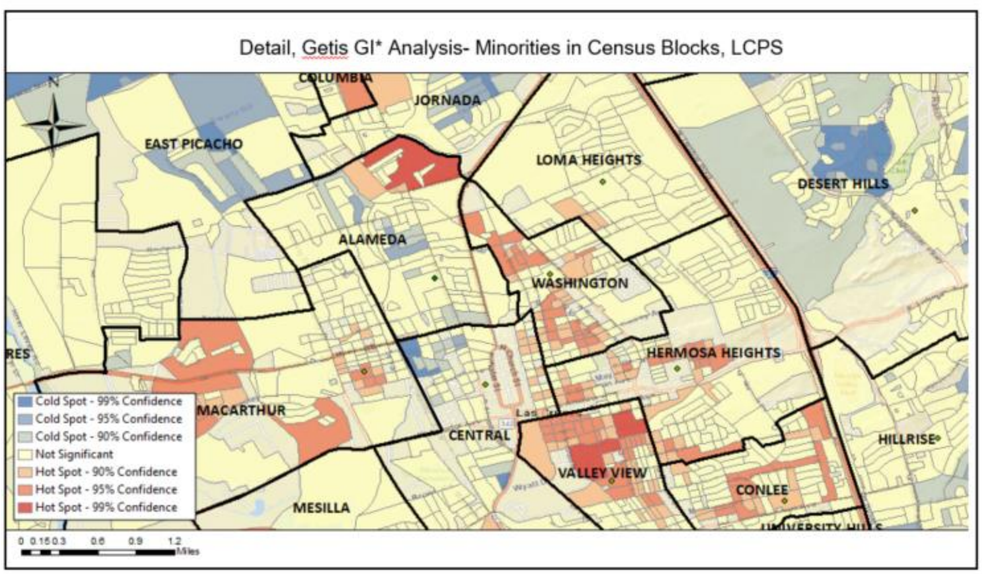
The original feature and the group of polygons surrounding it is considered a "neighborhood" in a hot spot analysis. All features around the neighborhood is the study area (in this case, the school district). Essentially, this analysis examines if the neighborhood derived from the feature is significantly different from the entire study area. The focus is not the feature, instead the focus is on comparing the neighborhood to the overall study area. If the neighborhood is significantly different then the feature (polygon) it is marked as hot spot (or cold). If the neighborhood is not statistically significant from the study area then it is marked as not significant. It is important to note that the location of hot spots is not synonymous with the location of the highest values. For example, if a high value feature has no surrounding high values then it won't be marked as a hot spot. Similarly, if a feature with a low value is surrounded by high values it could be marked as a hot spot because its average is brought up. The purpose of a hot spot analysis is only to identify areas of clustering that are not random. Results from the Getis Gi* are seen in Figure 29 and Figure 30. The patterns of red and blue indicate spatial clustering of minorities and the percentage confidence is indicated in the legend.

Figure 29: Getis GI* Analysis- Minorities in Census Blocks



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Figure 30: Getis GI* Analysis- Map Detail Minorities in Census Blocks

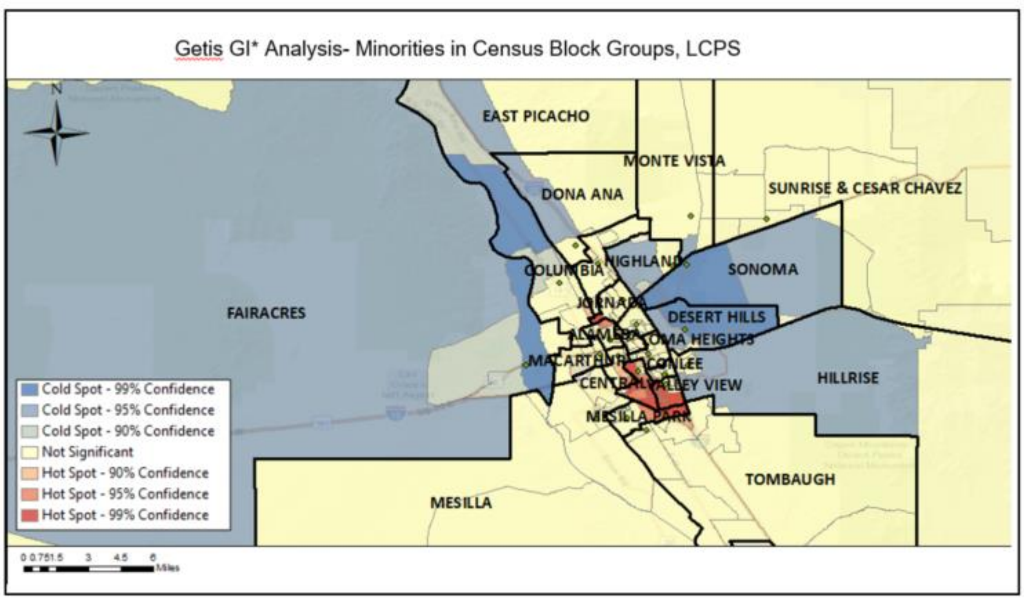


Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Results mirror patterns throughout this study; clustering of values significantly different from the overall study area in neighborhoods within Sonoma, Desert Hills, Sunrise, Fairacres, Doña Ana, and neighborhoods in the central region of Las Cruces.

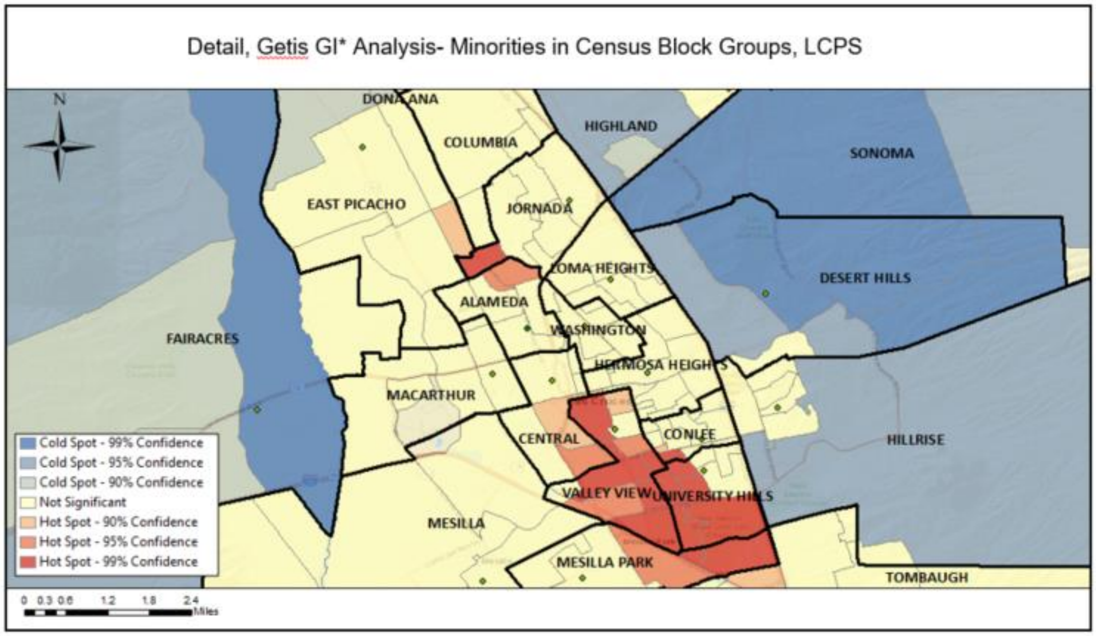
The GETIS-Ord Gi* analysis on students living in poverty in block groups also identified clusters of low values in blue and high values in red (Figure 31 and Figure 32).

Figure 31: Getis GI* Analysis- Poverty in Census Block Groups



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Figure 32: Detail, Getis GI* Analysis- Poverty in Census Block Groups



Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

Again, the maps identify high percentages of students in poverty clustered in block groups in the central region of the map and towards the university while clusters of low values (in blue) in the catchment zones east of downtown area and the catchment zones west of central Las Cruces. These analyses identified where there are high populations of minorities (and students living in poverty) that are clustered together rather than comparing the significance of low/high values. The GI BIN values (numbers on map in Figure 31) with a score of 2 or higher mean that there is spatial clustering.

The next analysis examined the possibility that the racial/ethnic and poverty composition of neighborhoods along adjoining boundaries would predict whether a student attends a high or low performing school. Initially I proposed conducting a geographically weighted regression analysis to compare blocks and block groups along adjoining boundaries of high and low performing schools in ArcGIS, the typical method used to study spatially varying relationships (Qiu and Wu 2011). However, this proved extremely difficult since the blocks and block groups in adjacent zones were irregular as explained earlier in the study. For example, in some zones the block groups were so large they nearly composed the entire school attendance zone. In other cases, blocks had no data in them. These two scenarios meant there were not enough blocks nor block groups along adjoining boundaries to make a GWR analysis feasible. Instead, I selected blocks (or block groups in the case of poverty) on adjoining boundaries of low and high performing schools and performed paired sample T-tests.

Paired sample T-tests were the most reasonable alternative since it allowed me to geographically compare the demographic data along the perimeters of "paired" high and low performing schools. According to Tobler's Law, which is the First Law of Geography, "everything is related to everything else, but near things are more related than distant things" (Tobler 1970). In other words, there should be little difference between the demographic composition of blocks and block groups that are directly next to each other, regardless if there is a school attendance boundary line dividing them. For this analysis, a high performing school was defined as a school at or above the mean level of academic proficiency in the district (51 percent) and low performing schools were defined as those scoring below the mean. Since the collinearity between race/ethnicity and poverty was identified earlier in the study, I analyzed race and poverty separately.

However, the irregularities in the geographic units meant blocks or block groups along the boundaries of schools could not be directly paired. Instead, I calculated the weighted mean minority rate of blocks along boundaries of low and high performing schools and assigned every school border region a mean value. The school border regions were then paired and the differences in means compared. The null hypothesis (H_o) stated that there was no significant difference between the mean minority rate in a high performing school's border region compared to the neighboring low performing school's border region. The alternative hypothesis (H_a) stated that there was a difference in the means between the border neighborhoods of low and high performing schools. The same process was employed to test the difference in mean poverty rates along borders. The resulting population sets include 12 pairs of borders examining differences in minority rates and 12 pairs for poverty rates (Table 22).

Table 22: High and Low Performing School Borders, Minority and Poverty T Test Pairs

High Performing (Minority)	*M*	*Low Performing (Minority)*	*M*	*High Performing (Poverty)*	*M*	*Low Performing (Poverty)*	*M*
HILLRISE	0.86	CONLEE	0.89	HILLRISE	0.280	CONLEE	0.379
DESERT HILLS	0.72	HERMOSA HEIGHTS	0.82	SONOMA	0.035	SUNRISE	0.248
DESERT HILLS	0.67	LOMA HEIGHTS	0.88	HILLRISE	0.020	SUNRISE	0.639
HIGHLAND	0.70	COLUMBIA	0.68	TOMBAUGH	0.123	MESILLA	0.216
FAIRACRES	0.79	MACARTHUR	0.93	MESILLA PARK	0.482	VALLEY VIEW	0.882
MONTE VISTA	0.83	SUNRISE	0.91	UNIVERSITY HILLS	0.876	VALLEY VIEW	0.903
SONOMA	0.79	SUNRISE	0.79	UNIVERSITY HILLS	0.566	CONLEE	0.509
UNIVERSITY HILLS	0.75	CONLEE	0.82	HIGHLAND	0.105	COLUMBIA	0.107
TOMBAUGH	0.12	MESILLA	0.22	DESERT HILLS	0.000	LOMA HEIGHTS	0.283
MESILLA PARK	0.48	VALLEY VIEW	0.88	DESERT HILLS	0.000	HERMOSA HEIGHT	0.245
EAST PICACHO	0.69	DONA ANA	0.73	HIGHLAND	0.105	JORNADA	0.310
HIGHLAND	0.64	JORNADA	0.73	EAST PICACHO	0.075	DONA ANA	0.166

Table 23 presents results from both paired sample T tests. The mean poverty rate in block groups along the boundary of a low performing school is much higher at 44 percent compared to a poverty rate of 25 percent for block groups along the boundaries of high performing schools. The tests for poverty show these results are occurring -3.4 standard deviations from the mean which is more than the critical one tail t of 1.796. The $p < .01$ so we reject the null hypothesis that there is no difference between the mean poverty rates of students living along the same attendance boundaries. In other words, on average, students living along an attendance boundary in the catchment zone of a low performing school have higher poverty rates than students living on the same boundary but within the zone of a high performing school.

Table 23: High and Low Performing School Borders, Paired Sample T Tests

	High Performing (Poverty)	Low Performing (Poverty)	High Performing (Minority)	Low Performing (Minority)
Mean	0.222	0.407	0.669	0.773
t Stat	-3.404*		-3.169*	
t Critical one-tail	1.796		1.80	

N= 12, * $p < .01$

Results from the paired sample t-tests on minority blocks on adjoining boundaries of low and high performing schools shared similar results. The mean minority rate for students residing along the boundary of catchment zones for low performing school was 77 percent minority compared to 67 percent minority along the boundaries of the catchment zones of higher performing schools. The null hypothesis was rejected in this analysis as well. Results are -3.169 deviations from the mean, which is more than the critical one tail t value of 1.8. This indicates that there is a significant difference between the mean minority rates in neighborhoods located along the boundaries of high performing schools compared to blocks along the boundaries of low performing schools. In addition, the $p < .01$ so the null hypothesis, that there is no difference between the mean minority rates of students living along the adjoining boundary of a high and low performing school attendance boundaries, was rejected.

In conclusion, both T tests supported my hypothesis that there would be a difference between the demographic composition of neighborhoods located on different sides of a shared school attendance boundary. In particular, the higher the percentage of Hispanic/Latinos (or students living in poverty) in a neighborhood along a school attendance boundary, the higher the likelihood they would attend a low performing school. These findings are important because there should be no significant difference between the demographics of neighborhoods along an adjoining school attendance boundary if boundaries are drawn to be inclusive of students from diverse backgrounds. However, these results must be understood within the context of the limitations of the geographic area. Although it is possible this is a result of boundary manipulation to exclude students, it is equally plausible, at least in some instances, that these findings are the result of boundaries drawn to follow natural barriers such as freeways or commercial structures.

8.7 Compare the socioeconomic composition of school attendance zones with an alternate model.

Previous school attendance boundary research has examined the shapes of school attendance boundaries to identify whether zones that are compact and centralized around a school point are more or less diverse than irregularly shaped school attendance boundaries (Bischoff 2008; Saporito and Sohoni 2006; Richards 2014).

Some scholars believe that compact school attendance boundaries replicate existing patterns of residential segregation, others believe irregular boundaries make zones more diverse, and yet some believe irregular zones are a tell-tale sign of gerrymandering (Johnson 2014; Richards 2015; Saporito and Van Riper 2016).

One way of measuring this is by creating Thiessen polygons (also known as Voronoi polygons). A Thiessen polygon defines an area of influence around its sample point, in this case the physical location of the school, so that any location inside the polygon is closer to that point than any of the other sample points (school) (Arlinghaus 1991). This analysis sought to compare existing LCPS zones to Thiessen polygons, in a similar manner to the research conducted by Arlinghaus (1991). The purpose of this step was to observe whether (hypothetical) catchment zones that are more centralized around a school are more or less diverse than the existing catchment zones which may be less centralized around their assigned school.

For this analysis, I calculated the socioeconomic composition of the zones using the same methodology as outlined in the previous steps and then compared the composition of the hypothetical zones with the composition of the current zones. Figure 33 illustrates a map of the Thiessen polygons (colored zones on the map) and the percentage poverty in each Thiessen zone. The original school attendance zones are overlaid on top of the Thiessen polygons.

The Thiessen polygons map show new Thiessen zones in the central part of the district have higher rate of poverty, like the original zones. A comparison of the original attendance zone values, compared to the new Thiessen value, and the percentage difference is represented in Table 24 for both poverty rates and minority rates.

Figure 33: Poverty Rates in Thiessen Polygons, Overlaid with School Attendance Boundaries

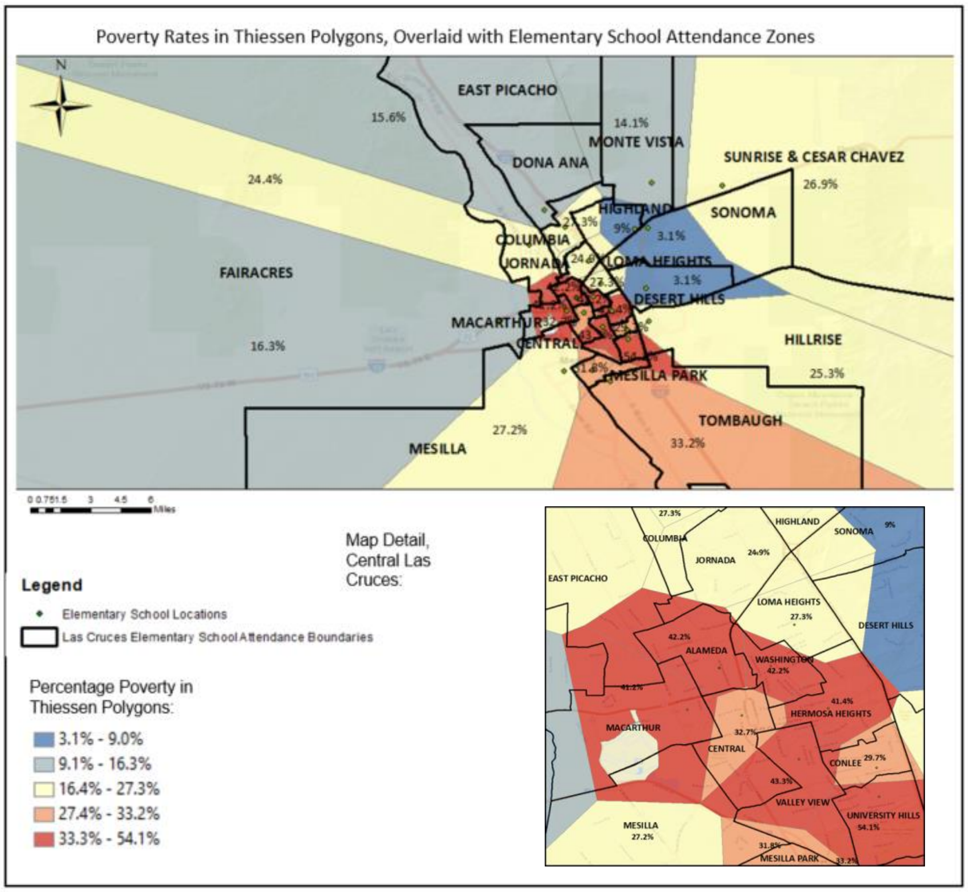
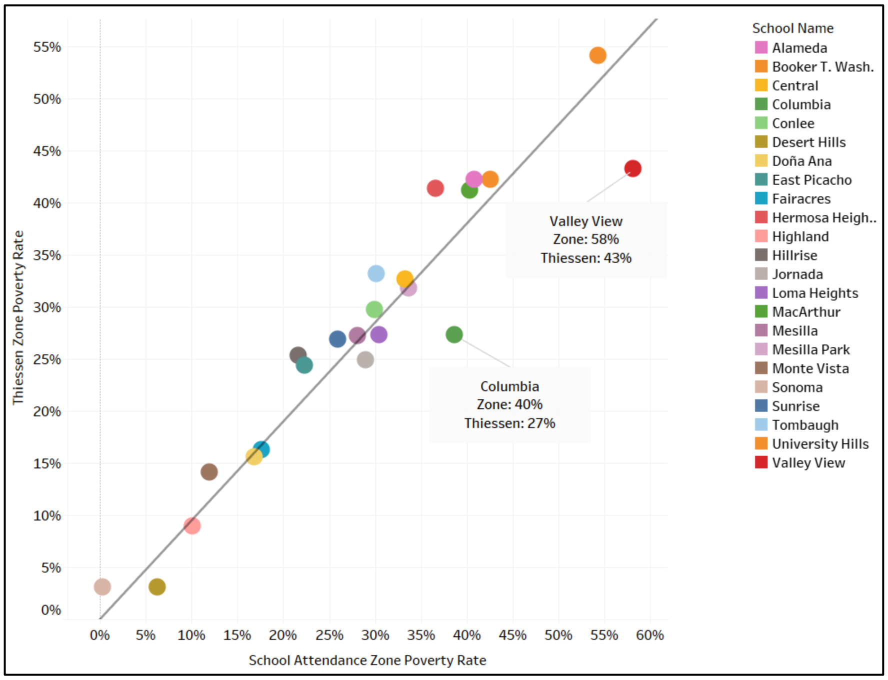


Table 24: Comparison: School Attendance Zones and Thiessen Polygons- Poverty Rates and Minority Rates

School Name	Thiessen Polygon (Poverty)	Current Zone (Poverty)	% Difference Poverty	Thiessen Polygon (Minority)	Current Zone (Minority)	% Difference Minority
Valley View	43.3%	58.1%	-14.8%	90.6%	88.6%	2.0%
Columbia	27.3%	38.7%	-11.4%	75.9%	84.3%	-8.4%
Jornada	24.9%	29.0%	-4.1%	76.8%	76.2%	0.6%
Desert Hills	3.1%	6.2%	-3.1%	61.1%	62.6%	-1.5%
Loma Heights	27.3%	30.4%	-3.1%	83.8%	86.9%	-3.1%
Mesilla Park	31.8%	33.7%	-1.9%	80.3%	81.1%	-0.8%
Fairacres	16.3%	17.6%	-1.3%	66.9%	68.4%	-1.5%
Doña Ana	15.6%	16.8%	-1.2%	78.8%	83.9%	-5.1%
Highland	9.0%	10.1%	-1.1%	68.8%	71.2%	-2.4%
Mesilla	27.2%	28.1%	-0.9%	64.3%	69.1%	-4.8%
Central	32.7%	33.3%	-0.6%	83.6%	85.6%	-2.0%
Booker T. Wash.	42.2%	42.6%	-0.4%	93.0%	93.0%	0.0%
Conlee	29.7%	29.9%	-0.2%	88.4%	89.8%	-1.4%
University Hills	54.1%	54.3%	-0.2%	71.9%	76.9%	-5.0%
MacArthur	41.2%	40.3%	0.9%	86.9%	91.2%	-4.3%
Sunrise	26.9%	25.9%	1.0%	81.6%	82.8%	-1.2%
Alameda	42.2%	40.8%	1.4%	79.6%	79.7%	-0.1%
East Picacho	24.4%	22.3%	2.1%	63.2%	68.7%	-5.5%
Monte Vista	14.1%	11.9%	2.2%	82.7%	78.5%	4.2%
Sonoma	3.1%	0.3%	2.8%	57.3%	65.4%	-8.1%
Tombaugh	33.2%	30.1%	3.1%	79.7%	76.2%	3.5%
Hillrise	25.3%	21.6%	3.7%	66.4%	66.6%	-0.2%
Hermosa Heights	41.4%	36.6%	4.8%	86.9%	87.2%	-0.3%

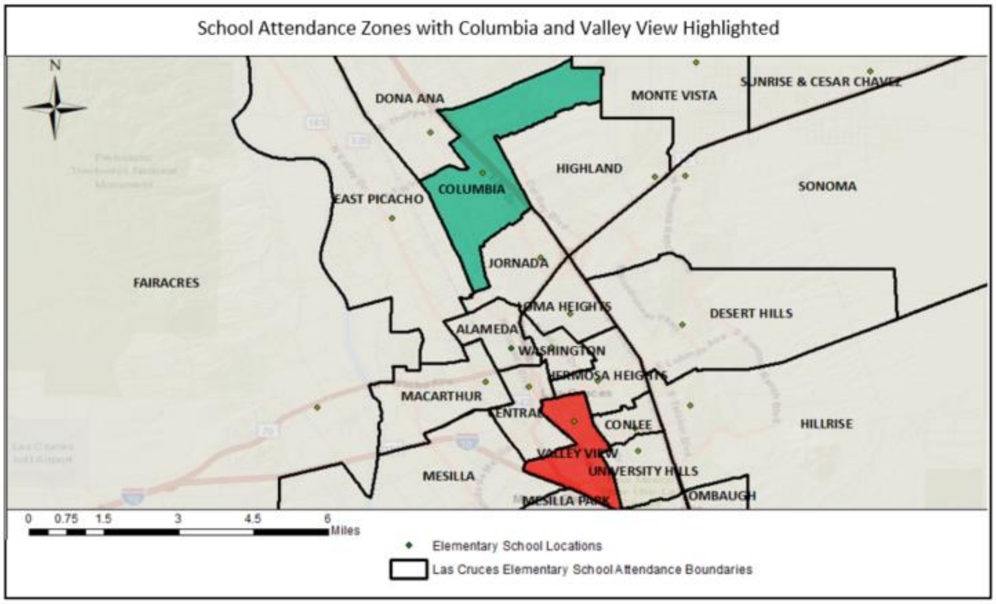
After reshaping these zones to be more centrally placed around the school, poverty rates decrease in most of schools (fourteen) while nine schools saw an increase in poverty. Two schools saw a dramatic drop in poverty with a drop of nearly 15 percent in the Valley View Elementary and 11 percent in the Columbia Elementary attendance zone. The scatterplot in Figure 34 further illustrates the differences.

Figure 34: Scatterplot of Poverty Rates in Zones Compared to Thiessen Polygons



Interestingly, these two school zones appear more irregularly shaped than most zones in the district, especially Columbia Elementary which cuts across a major highway (Figure 35).

Figure 75: School Attendance Zones with Columbia and Valley View Highlighted

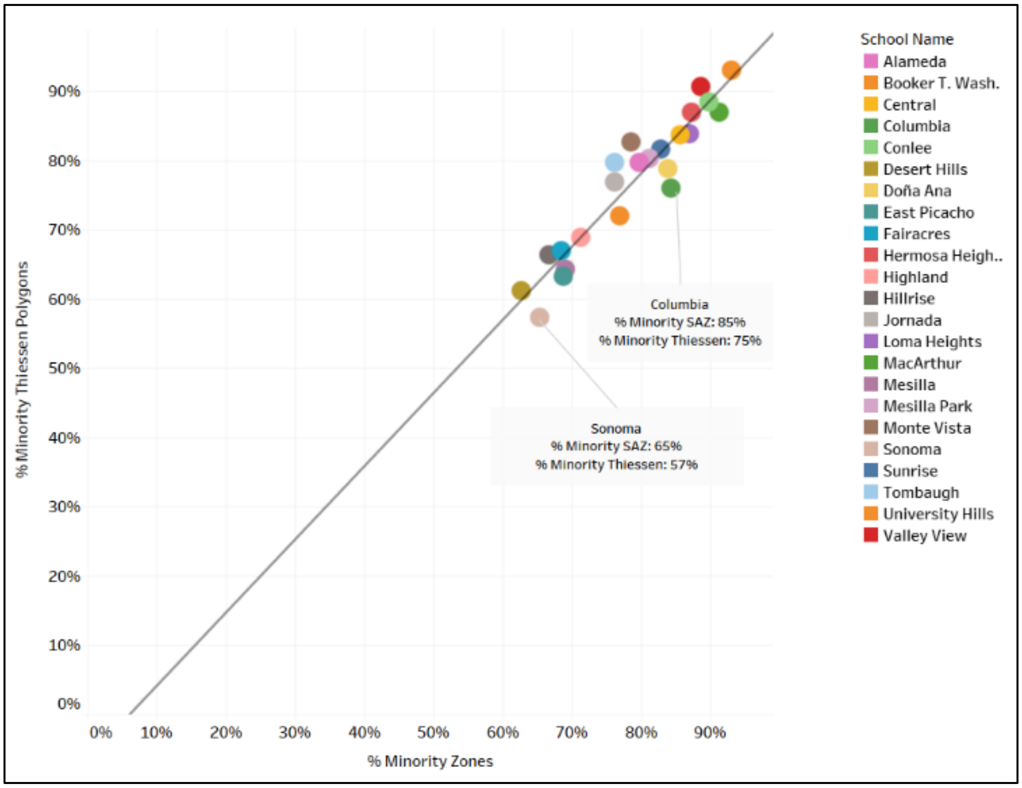


Sources: Las Cruces Public Schools, U.S. Census Bureau 2010-2014, ESRI

For these two schools, centralizing the zones around the school lessens the poverty rate in the school suggesting the irregularly shaped LCPS boundaries are not making the zones more diverse but less diverse. Future analysis could examine this further by measuring the shapes of the zones as done in previous research.

A comparison of the original school attendance zones and the Thiessen polygons for the minority rates revealed a less striking difference between the two models (Table 22 and Figure 36). Again, Columbia Elementary had the sharpest contrast between the two models with 8.4 percent fewer minorities in the Thiessen polygons compared to the original school attendance zone. Sonoma Elementary also shows 8.1 percent more minorities in the original zones compared to the Thiessen Polygon.

Figure 36: Scatterplot of Minorities in Thiessen Polygons and Original SAZs



The Theil H indices for the Thiessen polygons resulted in a value of 0.079 for poverty rates and 0.042 for minority rates across the district. I interpret these to mean that the average school attendance zone is nearly 8 percent less diverse (regarding poverty rates) than the entire school district and 4 percent less racially/ethnically diverse than the entire school district. According the Theil statistic, the Thiessen polygons result in a slight decrease in concentrations of poverty and minorities (Table 25). The lack of differences between the H values could be interpreted to mean that the current zones are, for the most part, centralized around the school point locations.

Table 25: Comparison of H values, School Attendance Zones and Thiessen Polygons- Poverty Rates and Minority Rates

H Current Zones (Poverty)	H Thiessen Polygon (Poverty)	Difference (Poverty)	H Current Zones (Minority)	H Thiessen Polygon (Minority)	Difference (Minority)
0.093	0.080	0.013	0.044	0.042	0.002

The Dissimilarity indices for the Thiessen polygons were compared to the Dissimilarity Indices for the attendance zones and are more intuitive to interpret. Results showed a slight decrease in segregation with the Thiessen Polygons (Table 26).

Table 26: Dissimilarity Indices: Zones Compared to Thiessen Polygons with Percent Difference

	(A) D Index Minority- Current SAZ	(B) D Index Minority- Thiessen Polygons	Difference Minority (A-B)	(C) D Index- Poverty Current SAZ	(D) D Index- Poverty Thiessen Polygons	Difference Poverty (C-D)
District	22.13	20.14	1.99	26.71	24.26	2.45

Table 26 indicates within the Thiessen Polygons, 20 percent (B) of the population would need to move for the race/ethnic distribution to mirror the district. In other words, segregation decreased approximately 2 percent after creating the Thiessen Polygons. Likewise, there was only 2.45 percent decrease in economic segregation after the construction off the Thiessen Polygons. In the new polygons, approximately 24 percent of students would need to change zones for economically disadvantaged students to be evenly distributed throughout the district.

I conducted a paired sample t test to test for statistically significant differences between the demographic composition of the current school attendance zones and the zones created by Thiessen polygons. The results in Table 27 show very similar average poverty rates and minority rates in the Thiessen polygons compared to the current zones.

Table 27: Paired Sample T Tests- Thiessen Polygons and Current School Attendance Zones

	Thiessen Attendance Zones (Poverty)	Current School Attendance Zones (Poverty)	Thiessen Attendance Zones (Minority)	Current School Attendance Zones (Minority)
Mean	0.276	0.286	0.769	0.789
t Stat	-1.040		-2.923*	
t Critical two-tail	2.074		2.074	

N= 23, * p < 0.01

The tests for poverty show the results are occurring 1.04 standard deviations from the mean. These results were not significant with a p value of .309 so we accept the null hypothesis that there is no difference between the means of current zones compared to the hypothetical zones created by the Thiessen polygons. Results from the paired sample t tests comparing the minority rates indicated the results are occurring 2.923 standard deviations from the mean. The results were significant with a p value of .003 so the null hypothesis can be rejected, there is a difference between the average rates of minorities in school attendance zones compared to the Thiessen polygons.

Although the Thiessen polygons indicate a statistically significant decrease in concentrations of minorities within zones, the decrease is numerically marginal. This is likely because the current placement of schools is similar to the Thiessen polygons, centrally located around the school point location. Redrawing the boundaries like Thiessen polygons would not alter the composition of the current zones in a dramatic way for most schools and would likely cause more inconvenience for families than benefits. However, redrawing boundaries in a different way could make the schools less segregated. Regardless of whether the district redraws the zones, they should examine how the boundaries could be drawn to be more equitable and diverse as new schools are added to the district.

9. DISCUSSION

There were five major research questions explored in this study, each of which is explained below then followed by theoretical implications.

Research Question 1: Does the racial/ethnic composition of each school attendance zone reflect the racial/ethnic composition of the school assigned to that zone?

Most of the school attendance zones reflected the racial/ethnic composition of their assigned school. There was a strong and significant relationship between the percentage of minority in schools and the percentage of minority in the zones. In fact, results suggested approximately 91 percent of students were attending the school they were geographically assigned to. However, I was surprised to find a few schools that deviated from the others. The most extreme case involved a school located in an area with high rates of poverty mixed with low rates of poverty. Three other schools with a discrepancy between the race/ethnicity of the zones compared to the schools, were located in the same area of town. One of these schools is in an area with high rates of poverty. Fewer white children than expected attended this school while nearby schools located in wealthier areas had higher than average numbers of white students in the schools. This finding agrees with previous research indicating schools located in neighborhoods with high rates of poverty result in white parents not enrolling their children in a neighborhood school.

Research Question 2: To what degree are elementary schools in Las Cruces Public School District and their attendance zones segregated?

School level results revealed a high degree of segregation between schools with high poverty rates and those without. A dissimilarity index of 45, indicated 45 percent of students would need to move to other schools for the poverty rates in each elementary school to reflect the poverty rate of the entire school district. Minorities were comparatively less segregated. For each school to mirror the racial and ethnic composition of the district, 27 percent of minorities would need to switch schools. Furthermore, correlation analyses demonstrated there was a strong and significant, positive relationship between minority and poverty rates in the schools.

The school attendance zones showed similar results for minorities but less segregation for students in poverty[10]. Results indicated 22 percent of students across the district would need to switch school attendance zones for the ethnic/racial composition of zones to reflect the racial/ethnic composition of the entire school district. In addition, 27 percent of students would need to change zones for the poverty levels in the zones to match the average poverty level of the district. The dissimilarity index for poverty in the zones was much lower than seen at the school

[10] However, the low rates of segregation seen at the geographic level could be considered less accurate since only students below 100 percent of the federal poverty level are included in the statistic compared to the school level measurement which includes students up to 185 percent of the federal poverty level. The latter is much more aligned with other poverty measures such as families receiving TANF or SNAP.

level because of the differences in measurement. Of course, “switching zones” is not a practical solution, however, redrawing boundaries might be. The higher degree of segregation according to poverty level in the zones (compared to ethnic/racial segregation) was also reflected in the nearly 60 percent spread between average poverty rate in the school zone with the highest rate of poverty and the school zone with the lowest rate of poverty.

Research Question 3: Is academic performance a function of the socioeconomic composition of the school and the socioeconomic composition of the school attendance zone?

Regression analyses also found a significant relationship between the socioeconomic composition the schools and academic performance. This relationship was negative revealing that nearly 60 percent of the variance in academic proficiency was attributed to the percentage of minorities in a school and 62 percent of the variance in academic proficiency was explained by the percentage poverty in a school. Moreover, academic performance was a function of the socioeconomic composition of the school attendance zones. In fact, for every percentage point increase in minority rates, academic achievement decreased by -0.847 percent and for every percentage point increase in poverty rates, academic achievement decreases -

0.422 percent. This suggests minority rates in schools are driving academic proficiency more so than poverty rates.

Analyses also found a significant relationship between the socioeconomic composition of school attendance zones and academic performance. Again, regression analyses indicated minority status is more of a predictor of academic performance compared to poverty, which only has a minimal effect. When controlling for poverty, for each percentage increase in minority in a zone, academic proficiency decreased -0.72 percent. This was significant with a p value of < 0.01. Results for the effects of poverty in the zones were not significant and only showed moderate significance after a possible outlier was removed from the model. In the latter case, when controlling for minority, for each percentage increase in poverty in a zone, academic proficiency decreased -0.295. The p value for poverty was 0.06, slightly over the recommended alpha of 0.05 meaning that the poverty results are at the margins of statistical significance. These results indicate proficiency is primarily explained by race/ethnicity in a school attendance zone, and poverty to a much lesser degree.

The school level results and school attendance zone results both agree academic performance is a function of minority rates in the zones and that higher minority rates in either schools or zones results in a decrease of academic proficiency. The relationship between poverty and academic proficiency appeared to have little or no effect on academic proficiency.

This finding is contrary to what is typically found in achievement gap research which indicates poverty is a higher predictor of academic proficiency compared to race or ethnicity. A possible reason for race and ethnicity driving academic proficiency could be patterns in access to early childhood education for children in this community. Research shows that children enrolled in high-quality, research-based early childhood education programs from birth to age 5 lead to much higher kindergarten readiness and 3rd grade reading scores. In Doña Ana County, the county in which Las Cruces resides, only 36 percent of children under the age of 5 and only 21 percent of children 2 years old and younger are enrolled in a free or subsidized early learning programs (Center for Community Analysis 2017). In addition, low rates of children enrolled in early childhood education in the county are linked to cultural preferences and economic barriers in the Hispanic/Latino community.

Seventy percent of children under the age of 5 in the county live in families that are low-income or are in poverty (Center for Community Analysis 2017). Approximately 36 percent of Hispanic children in the county live with, and are cared for, by grandparents (ACS 2014). In addition, 27 percent of families receiving childcare subsidies use registered childcare providers, the least regulated of all childcare providers. These providers are often located in neighborhood homes or the homes of extended family members. This is much higher than the average rate of 11 percent in the rest of New Mexico (Center for Community Analysis 2017). It is possible the lack of exposure to high-quality early childhood education programs for

Hispanic/Latino children in Las Cruces is resulting in a much lower rate of academic proficiency by third grade. Another factor may be the differences in education levels of parents in the community according to race and ethnicity. This is also known to greatly affect the number of words a child knows by age 3 and consequently 3rd grade reading scores (Harvard 2017). Another factor could also be the weakness of the model which is not picking up on the strong relationship between race/ethnicity and poverty. Regardless, future research could explore this in more detail.

Research Question 4: Does the socioeconomic composition of a neighborhood predict its inclusion into a high or low performing school?

Although predictive results were inconclusive, paired sample T-tests on neighboring blocks (or block groups) along the boundaries of high and low performing schools indicated statistically significant relationships between the mean socioeconomic[11] composition of blocks (or block groups) and the academic performance of the school. The mean minority rate in blocks along the boundary of a low performing school is 8 percent higher than blocks located on the opposite side of a boundary (in the zone of a high performing school). Likewise, block groups along boundaries that are located in the zone of a low performing school, had poverty rates

[11] "Socioeconomic," in this instance, is defined as the ethnic/racial and poverty composition.

19 percent higher than their companion block groups located school zones for higher performing schools. However, one should not conclude this is a result of gerrymandering, it could be the result of physical barriers (such as highways or large commercial developments) that mark the boundary between low and high performing schools. Regardless, it does draw attention to the need for a more in-depth analysis and consideration examining how boundaries can sort students according to race/ethnicity and class.

Research Question 5: How do the current socioeconomic compositions of school attendance zones compare with alternate models?

As hypothesized, there were some differences between the Thiessen polygon zones centrally located around a school point compared to the existing school attendance zones. Overall the differences were not large for the majority of schools with exception of two schools. The two largest differences between the two models for poverty rates (14.8 percent and 11.4 percent) were in school zones that were irregularly shaped. One zone in particular, Columbia Elementary, crosses a major freeway, which is atypical in this school district. This indicates that irregularly shaped zones, like those seen in several of the existing zones, did not make the zones more diverse in this study, instead they had the opposite effect, making them more segregated. However, most of the school zones did not differ greatly between models probably because most of the original zones are mostly centered around the school location. Likewise, the most significant decrease in minority rates (8.4 percent) with the Thiessen polygons occurred in the school whose current school attendance zone snaked across a major freeway. A comparison of the Dissimilarity indices of the original school attendance zones compared to Thiessen polygons showed segregation decreased approximately 2 percent for minorities within Thiessen polygons and almost two and a half percent for children living in poverty. Furthermore, a paired sample t test examining the statistical differences between the current zones and the Thiessen polygons only indicated a statistically significant decrease for minorities in zones.

Theoretical Implications

Social theorists such as Henri Lefebvre and David Harvey argue the social production of space is controlled by the hegemonic class to assert its power and reproduce the class structure. It is likely both theorists would include the creation of school attendance zones as an example of the social production of space that reproduces class structure. I agree with Lefebvre and Harvey. It is hard to ignore the evidence illustrating that school attendance zones contribute to the proliferation of segregated schools across the United States, and economics certainly plays a role in this. Although low-income students and underrepresented minorities have challenges outside of school that create obstacles to academic success, attending high poverty schools makes the achievement gap even greater. High poverty schools, which most minorities in the US attend, often lack the resources to create more opportunities for students to succeed. These schools typically have less qualified staff, less financial resources, less special programming, and fewer high level courses. This results in less academic success, including lower graduation rates. Consequently, the social and economic hierarchies remain the same with those in power retaining access to the high-quality resources such as high performing schools.

Bourdieu, on the other hand, might agree that school attendance boundaries are markers of social reproduction, although not necessarily imposed from a top-down hierarchy, but one that is continually being constructed out of habitus. In other words, school attendance boundaries may not be intentionally engineered to segregate, rather they reproduce the class structures that already exist in society. For example, the children of professional, wealthier children attend schools in their neighborhood which will be composed of children, parents and teachers of the same class. In addition, these families have more resources to contribute to public schools, including money, time, and social privilege allowing them to ask for more out of their schools, which in turn benefits their children. In this way, attendance zones replicate class structures.

Issues surrounding school attendance zoning, or any other type of geographic zoning is a combination of both intentional and unintentional social reproduction. Unintentional social reproduction could simply be the result of people naturally gravitating to neighborhoods where residents are more similar to themselves; whether economically or ethnically. It could also be the result of school districts placing schools where they are most convenient, or where there is land available with no intention of trying to segregate populations. However, it is equally true that in cities across the country, residents have fought to change school attendance boundaries or even redistricted to exclude minority and/or low-income students.

Although much research has shown the positive effects of school integration for low-income and minority students, there is still resistance to making this happen. For example, allocating a percentage of homes in higher income areas to public housing and intentionally designing school and district zones have proven successful for integrating schools. However, this is not the norm practiced in most cities. Instead, we have school districts splintering off into new districts as the ratio of minorities increase; as well as court cases undermining decades of integration efforts. A better understanding of the social implications of school zoning amongst school district employees, policy makers, and the public is needed to reduce segregation and improve educational opportunities for disadvantaged groups.

10. Conclusion

The purpose of this research was to explore the relationship between the socioeconomic composition of school attendance zones and school segregation as they relate to academic performance in a growing city with a large Hispanic/Latino population in the Southwest. This study contributes to the previous literature on school attendance zones and segregation by observing patterns of segregation in a relatively small, urban setting, in a predominantly Hispanic-Latino school district. In addition, this study offered new approaches to observing patterns of segregation by examining the spatial distribution of socioeconomic factors along the attendance boundaries of low and high performing schools.

I found a higher degree of economic segregation between schools compared to racial/ethnic segregation. Results were similar in the school attendance zones for the racial/ethnic distribution of students. However, there was lesser economic segregation in the school attendance zones compared to the schools. Findings also revealed an inverse relationship between the socioeconomic composition of the schools (and school attendance zones) and academic performance. In the school attendance zones, percentage minority had a larger effect on academic performance than poverty rates. Finally, there were significant differences between mean poverty and minority rates along the shared school attendance boundaries of low and high performing schools. High poverty and high minority neighborhoods were assigned to low performing schools and low poverty, low minority neighborhoods were assigned to high performing schools. This indicates school attendance boundaries serve as barriers that sort students according to socioeconomic composition.

This study aimed to stress the importance of paying close attention to socioeconomic residential patterns and the geographic shape of school catchment zones, especially as new schools are added to a school district. In the current climate of increased socioeconomic residential and school segregation across the United States, it is imperative that neighborhood schools do not proliferate into high-poverty hubs that segregate students. With the majority of children attending schools they are geographically assigned to, boundaries should be engineered to be inclusive of children from all backgrounds and neighborhoods, they should not reproduce patterns of inequality.

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