Title: Using GIS to explore the structural barriers to preparing economically disadvantaged students in Philadelphia's public high schools for undergraduate-level mathematics required in STEM majors

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ABSTRACT

The ability of individuals from underrepresented populations to enroll and complete postsecondary STEM programs relies on their academic preparation at the secondary level, among other factors. There are deep-rooted, enduring structural barriers to educational opportunity for African-American and Hispanic students, who often come from low-income urban communities. Specifically, the effects of concentrated poverty and school choice systems hinder the ability of high schools to graduate high percentages of economically disadvantaged students prepared for postsecondary STEM. I use the example of Philadelphia to demonstrate the interrelatedness of these structural barriers and school mathematics performance using state assessment (PSSA) scores. I show how GIS can be used as a tool to examine the problem.

KEYWORDS

secondary mathematics, college readiness, STEM, Pennsylvania System of School Assessment, African-American and Hispanic/Latino students, economically disadvantaged students, structural barriers, poverty, low-income communities, Philadelphia, high school choice, GIS, qualitative research

INTRODUCTION

This paper responds to the AAG call to generate ideas around a geographically-oriented research agenda to increase the participation of underrepresented populations (UPs) in postsecondary STEM. This project aims to contribute to a broader initiative, the NSF's "Science of Broadening Participation." With various stakeholders in mind, particularly policymakers, I attempt to address the following AAG questions:

- How can geographic research inform the larger academic enterprise engaged in developing a Science of Broadening Participation?
- How can geographic understanding and insights enrich efforts toward achieving diversity in higher education and the scientific workforce, particularly for geography and the spatial sciences?

In addition, I touch on the following questions listed among others in the NSF RFP letter:

- Under which conditions do social, economic, and socio-legal factors influence recruitment and retention into STEM education at both the individual, meso, and macro levels?
- How can social, political, economic, psychological, or other forces affect the identity and aspirations of underrepresented groups?

NATIONAL CRISIS

I focus on the importance of secondary mathematics preparation to improve college readiness, which supports student retention in postsecondary STEM programs--an ongoing recommendation to policymakers [1, 2]. In general, about 60 percent of *all* students enter college without the math skills needed to persist in STEM degree programs [2]. The Department of Education recently released data from its Civil Rights Data Collection showing vast inequalities in the advanced math course offerings across the nation's schools [3]. In addition, recent research promotes the development of a broader education policy agenda that targets economically disadvantaged students [4]: "the achievement gap between rich and poor children is double the gap between black and white children" and widening [5]. Moreover, the college completion gap, the strongest predictor of workforce success, has grown by 50 percent since the late 1980s [5].

According to the President's Council of Advisors on Science and Technology (PCAST), "…retaining more STEM majors is the lowest-cost, fastest policy option to provide the STEM professionals that the Nation needs for economic and social well-being" [2]. PCAST conveys that there needs to be a sense of urgency to better prepare UPs, considering that they constitute the fastest growing groups in the country.

- In 2009-10, 55% of high schools with low black and Hispanic enrollment offered calculus; the figure was 29% for schools with high-minority enrollment [3].
- Only about 20% of African-, Latino, and Native American (AALANA) aspirants complete STEM degrees [6].
- In 2006, AALANA minorities constituted only 9% of the nation's science and engineering labor force, while accounting for nearly 30% of the population [6].

LOCAL CONTEXT

There are just 2,000 high schools in major cities, including Philadelphia, that produce over 50 percent of America's dropouts [7]. Philadelphia Mayor Michael Nutter has a goal of cutting the rate of student dropout in half by 2014 [8]. While the School District of Philadelphia's (SDP) on-time graduation rate has increased recently, to 61 percent, there are massive numbers of minority students who may never engage in postsecondary experiences [9]. With the heightened political and civic interest in Philadelphia around public education right now, this city presents an excellent geographic example for exploring this national issue. I argue that in order to increase college-going rates of UPs--particularly economically disadvantaged students--in STEM, stakeholders must address persistent structural barriers to educational opportunity, specifically concentrated poverty and the high school choice system. The population that I focus on is the majority of Philadelphia high schools students, who are black and/or Hispanic, economically disadvantaged, and who attend low-performing schools. My topic constitutes one aspect of what should be a multi-faceted, concerted approach to fully address the problem.

- As of fall 2011, the SDP's K-12 population was 56% African-American and 19% Hispanic [10].
- A majority (81%) of SDP's students are economically disadvantaged [10].

BACKGROUND ON STRUCTURAL BARRIERS

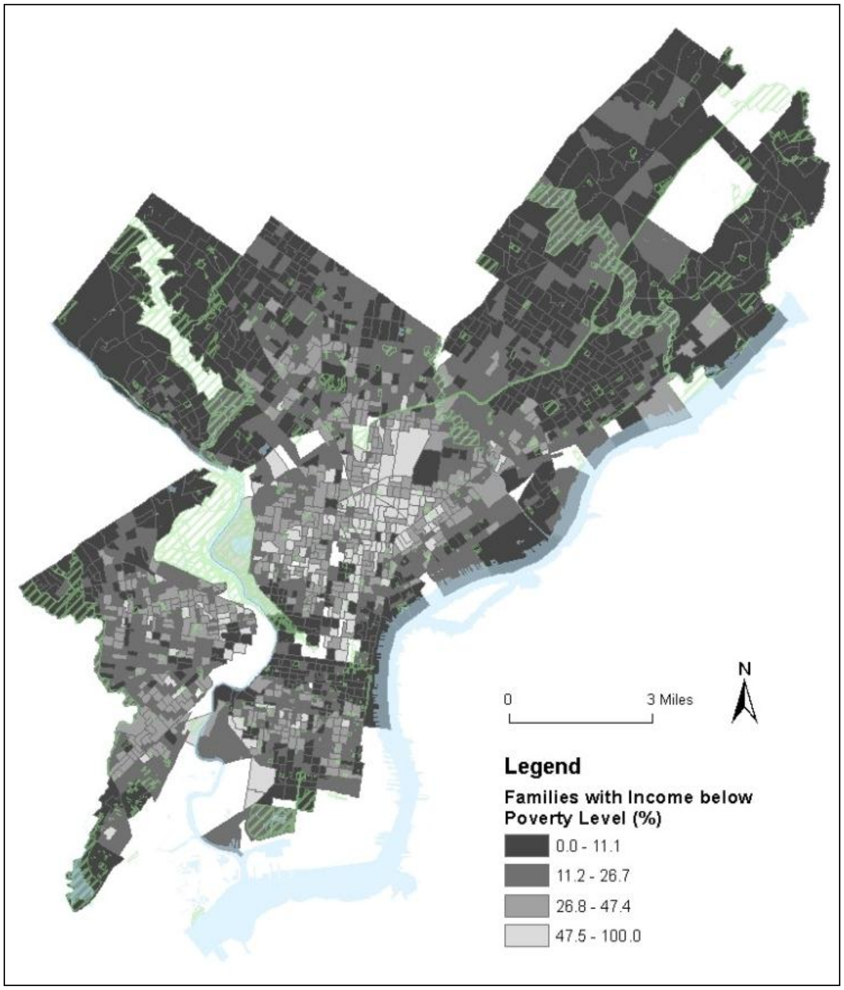
I outline two major structural barriers to the college readiness of economically disadvantaged students in mathematics: concentrated poverty and the school choice system in Philadelphia, which contribute to academic failure and exacerbate residential segregation.

CONCENTRATED POVERTY IN PHILADELPHIA

- The poverty of students is strongly correlated with school performance [11]. Schools with high percentages of students living in poor communities, often largely black or Hispanic neighborhoods, tend to be low-achieving. Figure 1 shows that there is concentrated poverty in north, southwest, and west Philadelphia. There are multiple ways that these conditions challenge the STEM aspirations of economically disadvantaged students: the inequitable distribution of resources across schools, low expectations, and lack of exposure to role models, information about career opportunities, and advanced courses [1].

- It's been found that high-income children start school at a significant academic advantage compared to low-income children. Academic enrichment activities often require time, money, and social capital. Examples include weekend sports, math tutors, and everyday parent-child interactions that acknowledge best practices for child development [5].

FIGURE 1: Philadelphia families below the poverty level (by block group)



SOURCE: 2000 Census data

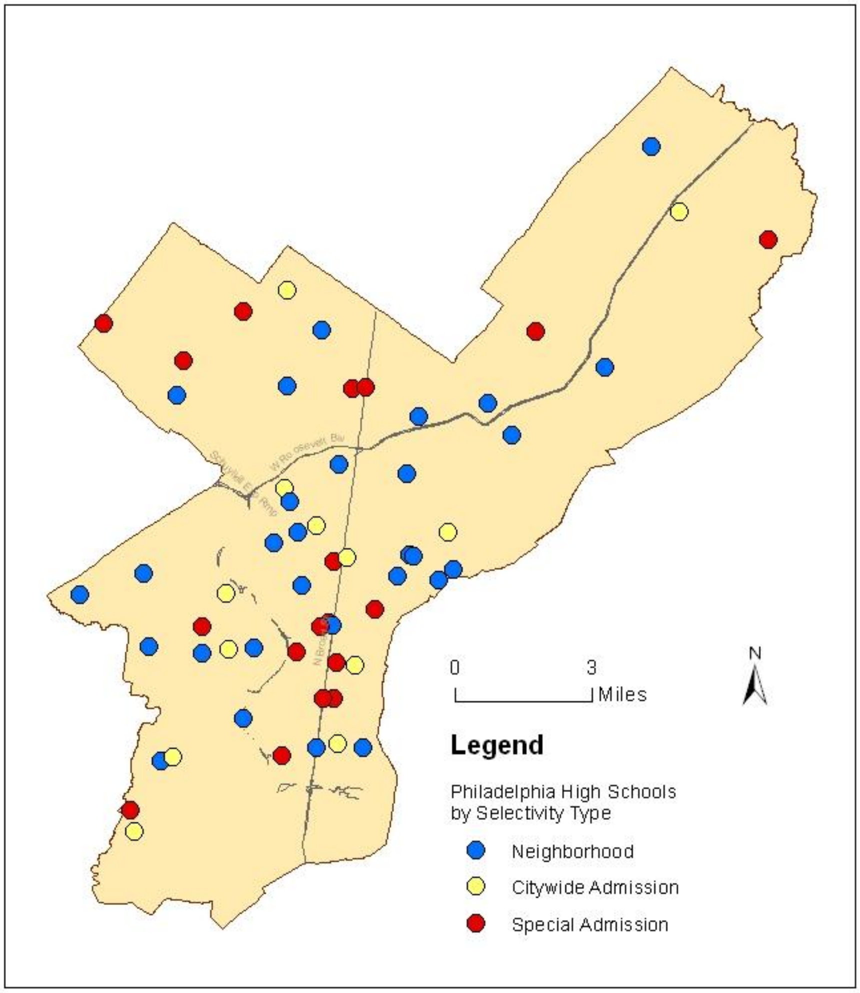
HIGH SCHOOL CHOICE IN PHILADELPHIA

- In Philadelphia, there are three types of traditional public high schools. The non-selective, neighborhood, schools admit all students within their feeder pattern or catchment area. They tend to have a reputation for being low-status and unsafe, which factor into higher incidents of teacher turnover [8]. Citywide admission schools require that applicants meet certain academic and behavioral criteria and then select students by computerized lottery. Special admission schools are the most selective, with high academic and behavioral requirements. This school year (2011-12), there are 25 neighborhood schools, 12 citywide admission schools, and 18 special admission schools.

- Figure 2 shows the "T" shape that the special admission schools form along the highly-accessible Broad Street subway line and stretching out into the relatively affluent northwest and northeast sections of the city. In contrast, most of the neighborhood schools are found in the poorest sections of the city, stretching along a diagonal from southwest to north Philadelphia.

- One report cites a disturbing finding about the high school choice system in Philadelphia, "…[I]n most cases, high schools are selecting students rather than students choosing schools, robbing students and families of the agency that school choice is supposed to provide" [8]. The researchers reported that black, Hispanic, and low-income students enrolled in neighborhood schools at higher rates than whites and Asians. Most students lacked the credentials to compete for the highly-coveted spots in selective schools and ended up not having much choice at all.

FIGURE 2: Philadelphia High Schools by Selectivity Type, 2012



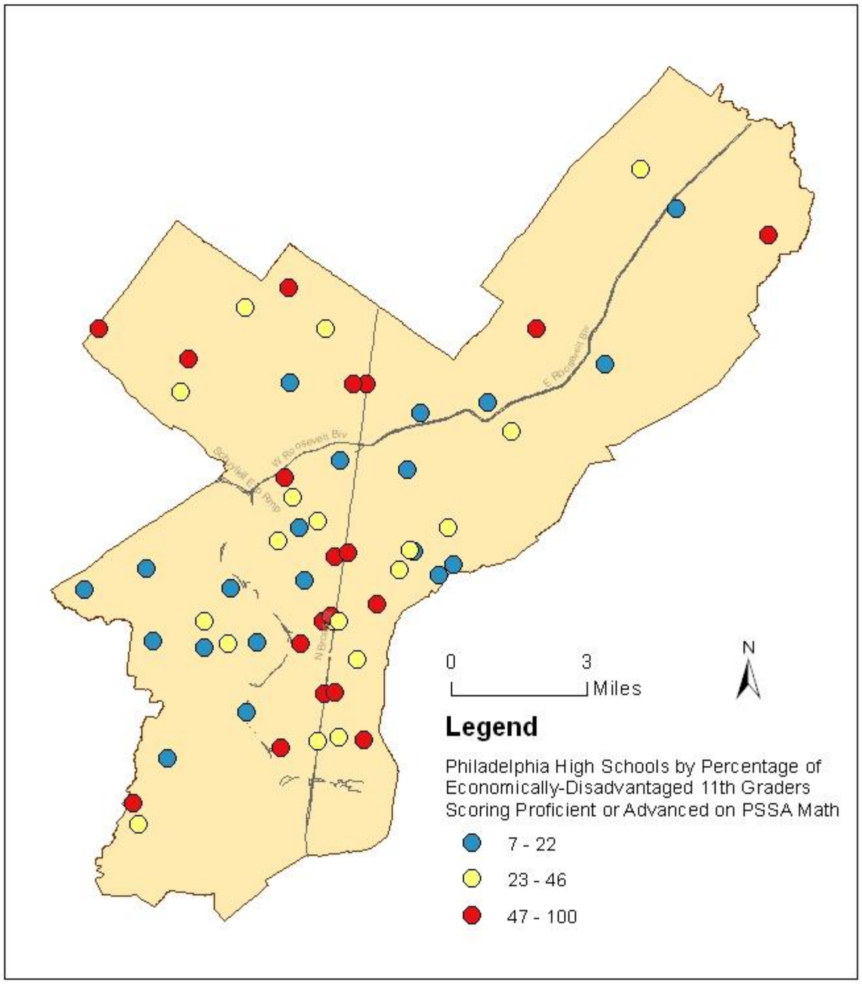
SOURCE: School District of Philadelphia, N=63

UNDER-PREPARATION IN MATHEMATICS

- The structural barriers described above contribute to the under-preparation of economically disadvantaged students in college mathematics required in STEM majors. Specifically, they produce schools of varying quality across the district, e.g., because of disproportionate access to safe environments, strong instruction, and college-prep classes.

- Figure 3 shows that at most high schools less than 50 percent of economically disadvantaged* 11th graders scored proficient or advanced in mathematics on the state assessment, administered spring 2011. The schools at or below the first tercile tend to be neighborhood schools located in poor communities. Note: Compare the color pattern to Figure 2 above. See the Appendix for a juxtaposition of all three maps.

FIGURE 3: Philadelphia High Schools by PSSA Math Performance (terciles), 2011



SOURCE: Pennsylvania Dept. of Education, N=60

GIS AS PART OF A MIXED-METHODS APPROACH

Maps have been valuable in examining the relationships between structural barriers and under-preparation of economically disadvantaged students in mathematics. One scholar suggests that GIS has "considerable potential to help theorize social phenomena by incorporating the spatiality of social processes" [12]. In addition, GIS enhances our ability to do the work of examining schools "in the context of the systems in which they function" [8].

* PDE advises LEAs to determine a student's eligibility of being "economically disadvantaged" according to poverty data sources such as Temporary Assistance for Needy Families cases, census poor, Medicaid, children living in institutions for the neglected or delinquent, or those supported in foster homes may be used. If such data are not available, they use the most recent reliable data available at the time of determination, such as free and reduced price lunch eligibility.

I suggest a mixed-methods approach to exploring how to increase participation of these students in STEM fields. GIS can provide a tool for:

- Database development and management, visualization, and querying to reveal the spatiality of under-preparation of economically disadvantaged high school students
- Exploring the relationships among different sociological processes, like poverty and educational opportunity
- Raising questions, e.g., Why are so many of the SDP's high-achieving high schools located centrally in the city, seemingly disconnected to residential communities?

At the same time, qualitative methods enable us to examine local phenomena closely to uncover processes that may be hidden by broad, quantitative analyses, and help to "address a holistic perspective that describes the interdependence and relatedness of complex phenomena" [13]. These methods can promote:

- The discovery of promising programmatic qualities at schools with high percentages of economically disadvantaged students who score proficient or advanced in math
- Answering not just the "what" but also the granular "how" about the processes and systems that effective schools use in preparing students for college-level math

DISCUSSION

The simple analyses above reveal the following:

- Schools with high percentages of economically disadvantaged students scoring proficient or advanced in math are almost always selective high schools.
- High school performance is not randomly distributed.
- There appear to be strong links among school type, school performance, and the economic characteristics of communities.

IMPLICATIONS

- We cannot ignore the structural barriers (e.g., concentrated poverty, high school choice systems) that are associated with academic achievement because they are impeding the ability of economically disadvantaged students to enter STEM fields. Some policy solutions need to be systemic.
- Grouping high percentages of poor students together is problematic for student achievement [11]. Perhaps students of different socioeconomic backgrounds and achievement levels ought to be more evenly distributed across the schools.
- An Executive Branch initiative includes "policies to recruit, support, retain, and reward" 100,000 STEM educators in 10 years [2]. As mentioned above, retaining teachers--esp. those who are able to provide high-quality instruction--in neighborhood schools has proven difficult. A comprehensive approach would address how to make these often troubled, dysfunctional schools places where educators and students want to stay. There needs to be structural changes in the high school choice system that make neighborhood schools more attractive to students and staff [8].
- Programmatic solutions are inadequate in addressing the problem in its entirety. Policymakers should be careful about imposing "one-size-fits-all" remedies. At the least, they should be context-oriented and place-specific. Fortunately, important work is underway in Philadelphia to turn around some of the city's lowest-performing high schools and early results appear promising [14].

- Students and parents cannot depend on neighborhood schools to provide the type of mathematics preparation required to excel in STEM. They may need to look outside of the school to access services that will meet their needs. These may include subsidized college prep programs happening after school or during the weekend. Accessing external resources involves a level of social capital that may be lacking in many communities. In addition, the services may not be available, which points to the need of cultivating partnerships among the SDP, community-based organizations, local colleges and universities, corporations, and other stakeholders. Some school leaders are already doing this [15].

QUESTIONS/NEXT STEPS

- Identify any neighborhood high schools that have large numbers of economically disadvantaged students scoring proficient or advanced in math. What are the characteristics of those schools and students?
- How are the city's 32 charter high schools situated amongst the other school types in terms of access and achievement?
- How can this paper contribute to the research agenda around the SBP?

CONCLUSION

Structural barriers hinder the ability of Philadelphia high schools, particularly those that are non-selective, to adequately prepare their students--mostly black, Hispanic, and low-income--for postsecondary mathematics. I have shown how GIS and spatial analysis can reveal the interrelatedness of sociological forces and student outcomes. Concentrated poverty and school choice systems, along with other long withstanding and highly-politicized issues, appear to be insurmountable challenges to equalizing educational opportunity. However, as acknowledged by multiple scholars [1], only a comprehensive approach that involves all stakeholders and addresses all factors that impact minorities' success in STEM will result in sustainable progress.

REFERENCES

[1] National Academy of Sciences. (2011). *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. Washington, DC: National Academies Press. Summary retrieved from http://www.nap.edu/catalog.php?record_id=12984

[2] President's Council of Advisors on Science and Technology. (2012, Feb. 7). Summary. Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Retrieved from http://www.whitehouse.gov/administration/eop/ostp/pcast

[3] Lewin, T. (2012, Mar. 6). Black Students Face More Discipline, Data Suggests. *The New York Times*. Retrieved from http://www.nytimes.com/2012/03/06/education/black-students-face-more-harsh-discipline-data-shows.html?_r=2&nl=todaysheadlines&emc=edit_th_20120306.

[4] Maxwell, L.A. (2012, Mar. 6). Growing Gaps Bring Focus on Poverty's Role in Schooling. *Education Week*. Retrieved from http://www.edweek.org/ew/articles/2012/03/07/23poverty_ep.h31.html?tkn=QYYFgsUqigQkeTfLtgpOzz3nMz6Sf3TbuZTr&cmp=clp-edweek&utm_source=fb&utm_medium=rss&utm_campaign=mrss

[5] Tavernise, S. (2012, Feb. 9). Education Gap Grows Between Rich and Poor, Studies Say. *The New York Times*. Retrieved from http://www.nytimes.com/2012/02/10/education/education-gap-grows-between-rich-and-poor-studies-show.html?_r=1&pagewanted=all.

[6] Hrabowski, F. A. (2011). Editorial: Boosting Minorities in Science. *Science, 331*, 125.

[7] The White House. (2010, Mar. 1). Press release: President Obama Announces Steps to Reduce Dropout Rate and Prepare Students for College and Careers. Retrieved from http://www.whitehouse.gov/the-press-office/president-obama-announces-steps-reduce-dropout-rate-and-prepare-students-college-an

[8] Research for Action. (Jan. 2010*). Policy Brief: Context, Conditions, and Consequences: Freshman Year Transition in Philadelphia*. Philadelphia: Research for Action. For more information, see the full report: *Transition to High School: School 'Choice' and Freshman Year in Philadelphia*.

[9] Socolar, P. (Feb. 2012). District on-time graduation rate surpasses 60 percent. *The Public School Notebook, 19* (4). Retrieved from http://www.thenotebook.org/february-2012/124482/district-time-graduation-rate-surpasses-60-percent. Figure is the percentage of students who entered 9th grade in fall 2007 and finished high school by 2011.

[10] School District of Philadelphia. Enrollment – District Operated Schools (Sept. 30, 2011). Retrieved from http://www.phila.k12.pa.us/about/#enrollment

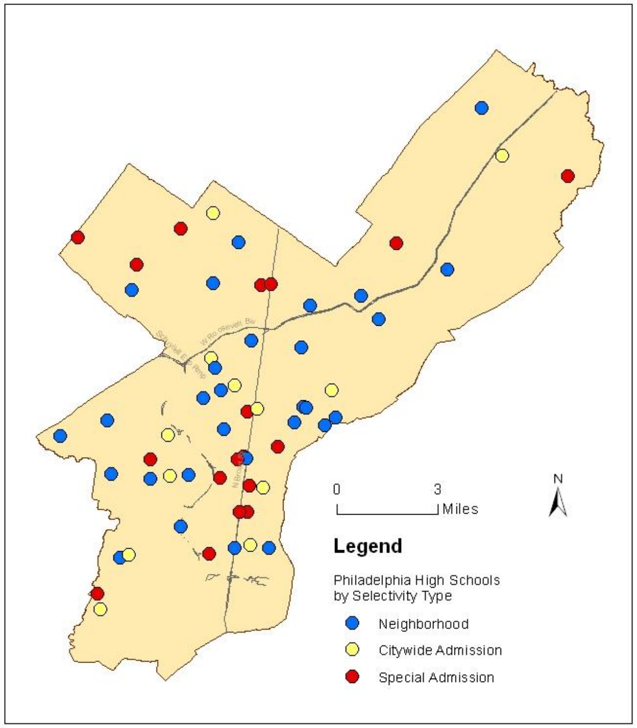
[11] Edmunds, K. (2009). Looking from the outside in: A spatial analysis of students' neighborhood characteristics and school performance in Philadelphia. (Master's thesis). University of Pennsylvania. ERIC Collection: ED512731.

[12] Pavlovskaya, M. (2006). Theorizing with GIS: a tool for critical geographies? *Environment and Planning A. 38*. 2003-2020.

[13] Patton, M. Q. (1990). *Qualitative Evaluation and Research Methods* (2nd ed.). Newbury Park, CA: Sage Publications, Inc.

[14] Research for Action. (Feb. 2012*). Executive Summary: Philadelphia's Renaissance Schools Initiative: 18 Month Interim Report*. Philadelphia: Research for Action.

[15] Graham, K.A. (2012, Feb. 27). Greater involvement by community and staff fills gaps at Phila. School. *The Philadelphia Inquirer*. Retrieved from http://www.philly.com/philly/education/20120227_Greater_involvement_by_community_and_staff_fills_gaps_at_Phila__school.html



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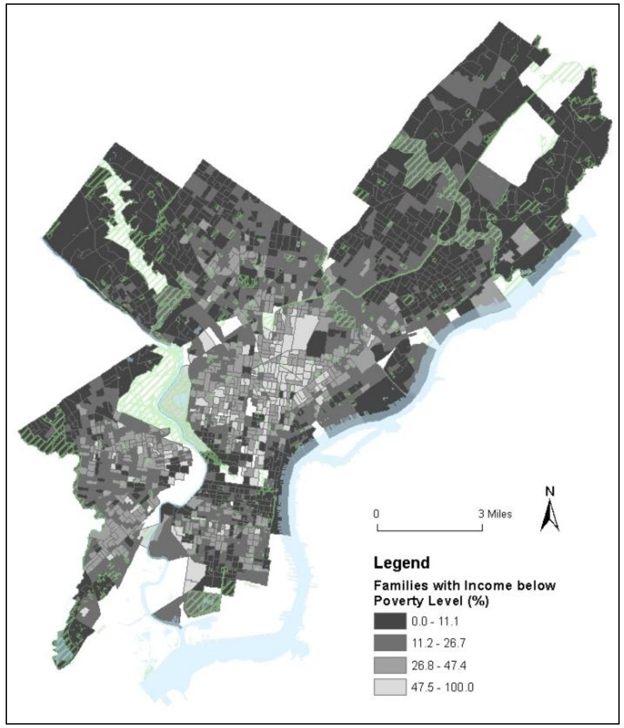
Philadelphia High Schools by Selectivity Type
Neighborhood
Citywide Admission
Special Admission



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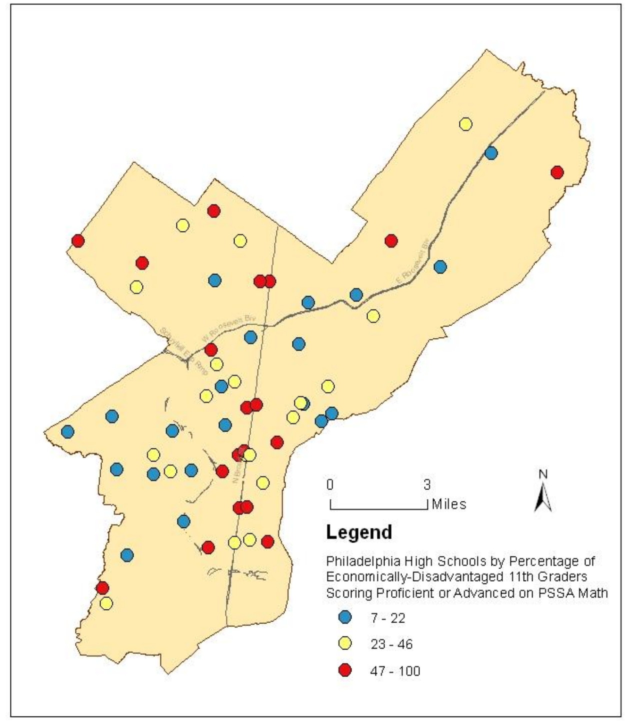
Families with Income below Poverty Level (%)
0.0 - 11.1
11.2 - 26.7
26.8 - 47.4
47.5 - 100.0



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Philadelphia High Schools by Percentage of Economically-Disadvantaged 11th Graders Scoring Proficient or Advanced on PSSA Math
7 - 22
23 - 46
47 - 100