Impact of Redlining on Modern Day STEM Course Offerings

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Abstract

This paper examines whether the legacy of historical redlining continues to shape access to advanced STEM coursework in U.S. public high schools. Using digitized HOLC maps linked to contemporary Civil Rights Data Collection and NCES data, I implement a boundary discontinuity design that compares schools located within 0.25 miles of historical redlining boundaries, holding constant broader neighborhood and city characteristics. A national analysis across 113 HOLC-mapped cities shows that schools in historically C- and D-rated neighborhoods are less likely to offer any advanced STEM course and offer substantially fewer calculus, computer science, and physics classes. City-level analyses of Chicago, Detroit, Philadelphia, and Los Angeles reveal similar but context-dependent patterns. These findings indicate that historical housing discrimination continues to shape the depth and distribution of STEM educational opportunity today.

1 Introduction

Historical redlining policies in the United States have had persistent and far-reaching effects on the spatial distribution of opportunity. The Home Owners' Loan Corporation (HOLC), established in 1933 to stabilize the housing market during the Great Depression, produced residential security maps that assigned neighborhoods grades from "A" (best) to "D" (hazardous). Although these maps were not the sole source of housing discrimination, they codified pre-existing racial and socioeconomic hierarchies into a formal system that shaped credit access, property values, and public investment for decades. Subsequent research has demonstrated that the HOLC's racialized risk assessments not only influenced housing markets but also reinforced patterns of urban inequality that continue to structure access to opportunity today (Aaronson et al. [2021]; Lukes and Cleveland [2021]).

This paper investigates whether the geography of redlining continues to shape access to advanced science, technology, engineering, and mathematics (STEM) coursework in American public schools. Access to advanced STEM education—such as calculus, physics, chemistry, and computer science—plays a crucial role in determining students' college readiness and long-term economic mobility. Yet opportunity to pursue these subjects remains unequally distributed across schools and neighborhoods. While prior studies have linked redlined neighborhoods to disparities in housing, health, and environmental outcomes (Appel [2016]; Hoffman et al. [2020]; Nardone et al. [2021]), few have examined whether redlining continues to shape educational opportunity in the domain of STEM.

Despite a growing body of evidence connecting historical redlining to modern socioeconomic outcomes, an important gap remains in understanding how these legacies manifest in educational opportunity structures, particularly in high-value academic areas like STEM. Existing studies—such as Lukes and Cleveland [2021]—demonstrate that redlined neighborhoods are associated with lower school funding, less diversity, and weaker student performance, but they focus primarily on overall achievement metrics. This paper extends that literature by examining STEM coursework access as a distinct and policy-relevant outcome that connects neighborhood history to long-term economic opportunity. Since STEM fields drive much of the modern labor market's wage growth and innovation, disparities in early access to STEM preparation perpetuate the broader racial and socioeconomic inequalities that redlining helped create. Identifying whether these disparities follow historical redlining boundaries can inform education policy and equity initiatives aimed at mitigating structural barriers to mobility.

To address this question, the study employs a boundary discontinuity design inspired by Aaronson et al. [2021]. Schools located within 0.25 miles of historical HOLC boundaries are compared across adjacent neighborhoods that received different HOLC grades. This approach isolates the local effects of redlining by holding constant broader city-level factors while accounting for modern neighborhood differences. The analysis proceeds in three parts. First, a national analysis is conducted across 113 metropolitan areas with at least three distinct HOLC zones (A–D) to estimate the average relationship between redlining and STEM access. Second, the study performs localized analyses for four major cities—Chicago, Los Angeles, Philadelphia, and Detroit—to explore regional variation in how redlining's legacy interacts with contemporary urban contexts. Together, these analyses aim to provide the first systematic evidence on whether the legacy of redlining extends to inequalities in advanced STEM education, highlighting how historical structures of exclusion continue to shape the geography of educational opportunity.

The remainder of this paper is organized as follows. The Literature Review provides historical background on the HOLC program, summarizes recent research on the modern consequences of redlining, and discusses the link between neighborhood context and educational outcomes. The Methods section outlines the empirical framework, including the boundary discontinuity design and estimation strategy. The Data section describes the sources used in the analysis, including the HOLC maps and Civil Rights Data Collection (CRDC). The Results section presents findings from the national and city-level analyses, while the Discussion interprets these results in light of policy implications and the broader literature on educational inequality. Finally, the Conclusion summarizes the key insights and identifies directions for future research on the long-term educational legacies of redlining.

2 Literature Review

2.1 HOLC History

The Home Owners' Loan Corporation was created in 1933 as part of the New Deal's effort to stabilize housing markets during the Great Depression. One of the agency's most consequential undertakings was the creation of "residential security maps" that graded neighborhoods based on perceived credit risk. These grades—A ("Best"), B ("Still Desirable"), C ("Definitely Declining"), and D ("Hazardous")—were based on a combination of housing conditions, socioeconomic characteristics, and, critically, racial composition (Jackson et al. [2016]; Hillier [2003]). The resulting maps were color-coded, with "redlined" D-graded neighborhoods typically marked by higher concentrations of Black residents, immigrants, and working-class populations.

Although the HOLC's stated purpose was to assess mortgage risk, its appraisal practices institutionalized racial prejudice within federal lending policy (Crossney and Bartelt [2005]; Michney and Winling [2020]). HOLC assessors drew on local realtors and bankers who frequently described racial "infiltration" as a cause for neighborhood decline, embedding racial and ethnic bias into the official record (Hillier [2003]). These maps were subsequently used by the Federal Housing Administration (FHA) and private lenders to restrict mortgage credit, further entrenching patterns of segregation and disinvestment (Greer [2013]; Aaronson et al. [2021]).

While scholars debate whether the HOLC itself originated redlining or simply reflected existing racial divisions (Fishback et al. [2022]), there is broad consensus that its maps shaped the geography of opportunity for generations. They provided a federally sanctioned template that justified unequal investment, influencing where banks lent, where infrastructure developed, and where families could accumulate wealth (Appel [2016]). By codifying racial risk into financial decision-making, the HOLC helped institutionalize the spatial segregation that continues to define American cities today.

2.2 Modern Outcomes of HOLC

Over the past decade, researchers have connected the geography of redlining to a wide range of contemporary social and economic disparities. Using digitized HOLC maps, scholars have shown that formerly redlined areas continue to exhibit lower home values, lower household incomes, and higher racial segregation (Aaronson et al. [2021]; Appel [2016]; Krimmel [2018]). Beyond housing, these areas also show worse environmental and health outcomes—they experience higher exposure to air pollution, urban heat, and chronic disease (Hoffman et al. [2020]; Nardone et al. [2021]; Namin et al. [2020]).

Importantly, redlining's effects extend into the educational domain. Lukes and Cleveland (Lukes and Cleveland [2021]) provide one of the first comprehensive analyses linking HOLC grades to school funding, diversity, and academic performance. They find that schools located in formerly redlined neighborhoods receive significantly less per-pupil revenue, enroll more racially homogeneous student bodies, and have lower average test scores. These findings suggest that historical redlining has a durable influence on the distribution of educational resources, even after controlling for contemporary socioeconomic conditions.

Other scholars echo these patterns. Aaronson et al. (Aaronson et al. [2021]) find persistent disparities in property values and income across HOLC boundaries, implying that local tax bases—and thus school funding—remain affected. Faber (Faber [2021]) demonstrates that redlining amplified racial wealth gaps by shaping who benefited from mid-century housing subsidies. Collectively, this literature portrays redlining as a foundational mechanism linking historical racial exclusion to contemporary inequality across multiple domains. Yet despite growing recognition of redlining's educational consequences, few studies directly examine whether its legacy extends to STEM coursework access, an increasingly important dimension of academic opportunity and future labor market participation.

2.3 The Relationship Between Schools, Neighborhoods, and Student Outcomes

Education systems are deeply intertwined with neighborhood contexts. In the United States, school funding structures rely heavily on local property taxes, meaning that differences in neighborhood wealth directly translate into differences in educational resources (Jackson et al. [2016]; Lafortune et al. [2018]). Because redlining constrained homeownership and suppressed property values in Black and immigrant neighborhoods, it indirectly limited the fiscal capacity of their local schools. Decades of research show that school resources matter for long-term outcomes: districts that received funding increases after school-finance reforms saw higher graduation rates and adult earnings among low-income students (Jackson et al. [2016]).

Neighborhood effects extend beyond funding. Residential segregation—reinforced by redlining—shapes peer composition, teacher quality, and access to advanced coursework (Reardon et al. [2019]; Owens [2018]). Students in racially and economically segregated schools have fewer opportunities to take advanced placement (AP) courses and less exposure to high-level math and science curricula (Card and Giuliano [2016]). Because STEM course access is a strong predictor of postsecondary achievement and STEM degree completion, these early disparities have compounding effects on social mobility (Maltese and Tai [2011]).

Neighborhood opportunity also influences long-term life trajectories. Chetty and Hendren (Chetty and Hendren [2018a]; Chetty and Hendren [2018b]) show that children who grow up in higher-opportunity neighborhoods—defined by income mobility and school quality—achieve higher adult earnings and educational attainment. Historical redlining shaped these neighborhood opportunity structures, meaning that children today may still inherit the consequences of 1930s credit maps through the schools available to them. By examining whether schools in formerly redlined areas are less likely to offer advanced STEM courses, this study extends existing work on redlining and education to a new dimension of academic inequality.

Ultimately, the literature suggests that the HOLC's spatial imprint remains visible in today's educational landscape. Schools continue to reflect the socioeconomic contours of the neighborhoods they serve, and those contours were, in part, drawn nearly a century ago by federal policy. By linking historical redlining to modern STEM access, this paper provides new evidence on how spatially embedded inequalities continue to constrain pathways into high-opportunity fields, reinforcing intergenerational disparities in human capital formation.

3 Methodology

3.1 Data

This study integrates historical redlining maps with contemporary school-level administrative data to examine whether the legacy of HOLC neighborhood ratings continues to shape access to advanced STEM coursework. The analysis combines (1) digitized 1935–1940 HOLC residential security maps from the Mapping Inequality Project, (2) the 2021–22 National Center for Education Statistics (NCES) Common Core of Data (CCD) Public School Universe file, and (3) the 2020–21 Civil Rights Data Collection (CRDC). All spatial processing and file merging were conducted in Python using geopandas, shapely, pandas, and numpy.

3.1.1 HOLC Maps

The primary historical data source consists of digitized HOLC residential security maps produced between 1935 and 1940. These maps were originally created by the Home Owners' Loan Corporation to guide mortgage refinancing decisions and assign neighborhoods grades from "A" (Best) to "D" (Hazardous). The digitized files used in this study come from the Mapping Inequality Project (Nelson et al., 2020), which provides complete GIS polygon files for nearly 240 U.S. cities, including polygon geometries, HOLC grade labels, and transcribed area descriptions. All maps were downloaded in GeoJSON format and reprojected from their original coordinate systems into EPSG:3857 for spatial analysis.

To construct the national analytic sample, I first identified all HOLC-mapped cities containing at least three distinct HOLC grade types (A, B, C, and D). Cities lacking this minimum variation were excluded, following the logic that boundary-discontinuity identification requires meaningful grade contrasts. This filtering process resulted in 113 eligible cities. For each city, I extracted the polygon geometries and generated 0.25-mile buffers (converted to meters) around the boundary lines separating adjacent HOLC grades. These buffers were used to identify schools located near historical grade transitions.

Schools were assigned to HOLC grades using a point-in-polygon spatial join. Each school received the grade of the HOLC polygon it physically intersected, and all schools outside any HOLC polygon were excluded. In line with boundary design conventions, I further restricted the sample to schools located within 0.25 miles of a HOLC boundary, ensuring that comparisons were made between schools in close geographic proximity but on opposite sides of historically distinct rating lines.

Across the 113 included cities, this process yielded a final national analytic dataset of 1,767 schools located both within HOLC coverage and within the 0.25-mile boundary zone.

3.1.2 NCES CCD Data

To identify school coordinates and basic institutional characteristics, I used the 2021–22 NCES Common Core of Data (CCD) Public School Universe file. This dataset provides school-level attributes for all U.S. public schools, including latitude (LATCOD), longitude (LONCOD), school grade span, state and district identifiers, and Title I eligibility. Since the CCD includes separate files for public and private schools, only public schools were present in the dataset used for this analysis, eliminating the need for manual removal of private institutions.

School coordinates were projected into EPSG:3857 to match the reprojection of the HOLC files before executing spatial joins. Schools were restricted to those serving grades 9 through 12, defined as any school whose grade span included both 9th and 12th grade. This filtering ensured that only institutions capable of offering advanced STEM coursework—typically offered in high school—were included.

The CCD variable for Title I status was originally categorical; I recoded this into a binary indicator for use as a control in regressions. All other demographic, staffing, and enrollment variables were obtained from the CRDC dataset (see below), as the relevant CCD fields were incomplete or missing for many schools in the years used.

3.1.3 CRCD Data

The 2020–21 Civil Rights Data Collection (CRDC) provides detailed school-level information on course offerings, teacher staffing, student demographics, and program participation. This dataset served as the primary source for constructing the STEM access outcome variables and for deriving control variables related to school composition and instructional resources.

STEM course access was measured using CRDC fields indicating whether a school offered calculus, physics, chemistry, or computer science. These variables were used to construct (1) a binary indicator equal to 1 if a school offered any advanced STEM course, and (2) a count variable reflecting the total number of distinct advanced STEM subjects available. For visualization purposes, I additionally used the raw CRDC variables to examine the prevalence of specific courses across HOLC grades, though these subject-specific measures were not used directly in regressions.

The CRDC also provided information on school-level enrollment, teacher counts, certified teacher counts, racial/ethnic composition, and charter/magnet status. Charter and magnet schools were retained but marked with indicator variables for all empirical models. Some variables, particularly total enrollment, exhibited missingness across cities; schools missing CRDC course-offering data were dropped from the analytic sample to ensure consistent measurement of the outcome.

All CRDC data were merged with CCD data using the NCESSCH unique school identifier.

3.2 Sample Construction

After merging the HOLC, CCD, and CRDC datasets, the final national analysis sample includes only schools that:

1. Are public schools (from CCD Public School Universe),
2. Serve grades 9–12,
3. Fall inside a HOLC polygon,
4. Are located within 0.25 miles of a HOLC boundary, and
5. Have non-missing CRDC STEM course data.

For city-specific analyses, I restricted the dataset to schools within the HOLC-covered area of each city (Chicago, Los Angeles, Philadelphia, Detroit) and applied the same boundary-based 0.25-mile inclusion rule. Separate regressions were run for each city.

3.3 Empirical Strategy

The objective of this study is to estimate whether schools located in historically lower-rated HOLC neighborhoods (Grades C and D) exhibit reduced access to advanced STEM coursework compared to schools in higher-rated neighborhoods (Grades A and B). To isolate the local, quasi-experimental variation produced by discontinuities in HOLC grading, the analysis employs a boundary discontinuity design following Aaronson, Hartley, and Mazumder (2021). This design compares schools in close geographic proximity but assigned to different HOLC grades, thereby holding constant broader spatial factors that evolve smoothly across neighborhoods.

3.3.1 Boundary Discontinuity Framework

HOLC maps exhibit sharp changes in assigned credit grades at their boundaries. These historical grading breaks represent discontinuous variation in perceived mortgage risk that is plausibly exogenous to modern school-level characteristics once contemporary controls are included. To leverage this variation, I restrict the sample to schools located within 0.25 miles (402 meters) of any boundary between two different HOLC grades. This buffer is constructed around the boundary lines separating HOLC polygons.

Each boundary line segment is treated as a comparison unit. Schools are assigned to the boundary_id of the segment whose buffer they fall within. Schools also receive the HOLC grade of the polygon they physically intersect. Schools outside any HOLC polygon or farther than 0.25 miles from any boundary are excluded. This creates a two-sided local comparison sample in which schools on opposite sides of the same historical boundary line are compared.

Identification is obtained by including boundary fixed effects, which absorb all unobserved, boundary-specific characteristics—such as localized housing stock, neighborhood development patterns, and historical socioeconomic conditions. Because the buffer window is narrow, and because schools on both sides are equidistant from the same boundary, the identifying assumption is that potential outcomes would vary smoothly in the absence of historical HOLC grade differences.

3.3.2 Regression Models

The primary model for the binary indicator of STEM access is a logistic regression of the form:

$$\text{logit}(AnySTEM_i) = \alpha + \beta \cdot Redline_i + \gamma X_i + \eta_{b(i)} + \varepsilon_i, \tag{1}$$

where (AnySTEM_i = 1) if school i offers calculus, physics, chemistry, or computer science, (Redline_i = 1) if school i is located in a C or D HOLC area. (X_i) represents school-level controls: Title I indicator, charter school indicator, magnet school indicator, and percent certified teachers. (\eta_{b(i)}) denotes boundary fixed effects, ensuring that identification comes entirely from variation across schools lying on opposite sides of the same historical boundary. Standard errors are clustered at the boundary segment level, consistent with the identification design.

To examine the extensive and intensive margins of STEM access, I also estimate a negative binomial regression for the number of advanced STEM subjects offered:

$$NB(TotalSTEM_i) = \alpha + \beta \cdot Redline_i + \gamma X_i + \eta_{b(i)} + \varepsilon_i, \tag{2}$$

where (TotalSTEM_i) equals the total number of distinct advanced STEM subjects offered (calculus, physics, chemistry, computer science). This model uses a negative binomial specification to account for the over-dispersed distribution of course offerings. Boundary fixed effects and the same set of controls (X_i) are included, mirroring the binary outcome model.

Together, these models estimate whether historically lower-rated HOLC areas exhibit lower probabilities of offering any advanced STEM course and reduced breadth in STEM offerings.

3.3.3 National and City-Level Analyses

Both models are estimated on a national dataset of 1,767 schools across 113 HOLC-mapped cities that contain at least three HOLC grade types. To examine regional heterogeneity, I estimate separate regressions for Chicago, Los Angeles, Philadelphia, and Detroit. Each city-specific sample includes only schools located within that city's HOLC-mapped area and within 0.25 miles of at least one HOLC boundary. The same model specification and boundary fixed effects are used in all analyses.

3.3.4 Identification Assumptions

The key assumption is that, conditional on controls and boundary fixed effects, potential outcomes vary smoothly within the narrow spatial window around each HOLC boundary. Under this assumption, any systematic difference in STEM access across boundaries can be attributed to historical HOLC grade assignment. Because identification occurs within the same boundary segment, broader city-level and district-level differences are not sources of bias.

3.3.5 Software and Implementation

Spatial operations—including coordinate reprojection, buffer construction, boundary assignment, and polygon intersections—were performed in Python using geopandas, shapely, and pandas. Regressions were estimated with statsmodels, with standard errors clustered at the boundary level.

4 Results

4.1 National Level

4.1.1 National Level Descriptive Patterns

Across the national sample of 1,767 high schools located within 0.25 miles of a historical HOLC boundary, access to advanced STEM coursework declines consistently across the HOLC grading scale. Figure 1 presents predicted probabilities from the logistic regression model. Schools in formerly "A" neighborhoods exhibit the highest likelihood of offering at least one advanced STEM course (approximately 0.80), while those in "D" neighborhoods show probabilities closer to 0.74. Although the overall decline appears modest, it is monotonic and precisely aligned with expectations surrounding redlining's long-term effects.

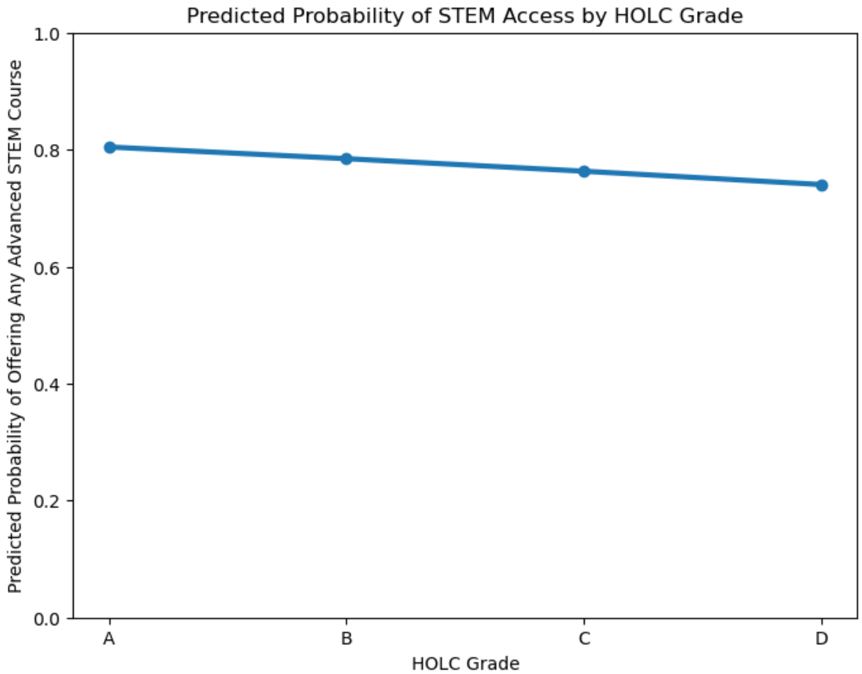

Figure 1. Predicted Probability of Offering ≥1 Advanced STEM Course, by HOLC Grade

Notes: This figure displays predicted probabilities from a logistic regression model estimating the likelihood that a school offers at least one advanced STEM course (calculus, physics, computer science, chemistry). Predictions hold Title I status, charter/magnet status, and percent of certified teachers at their sample means. The downward trend from A to D indicates that schools located in historically lower-rated HOLC neighborhoods exhibit systematically reduced access to advanced STEM coursework.

Descriptive distributions of the number of STEM subjects offered reinforce this pattern. Figure 2 shows the percent of schools offering 0, 1, 2, or 3 advanced STEM subjects by HOLC grade. Schools in A-rated areas are far more likely to offer all three courses (44.2%), while only 21.2% of schools in D-rated areas do so. Conversely, the share of schools offering no advanced STEM subjects increases from 20.9% in A-rated areas to 26.9% in D-rated neighborhoods.

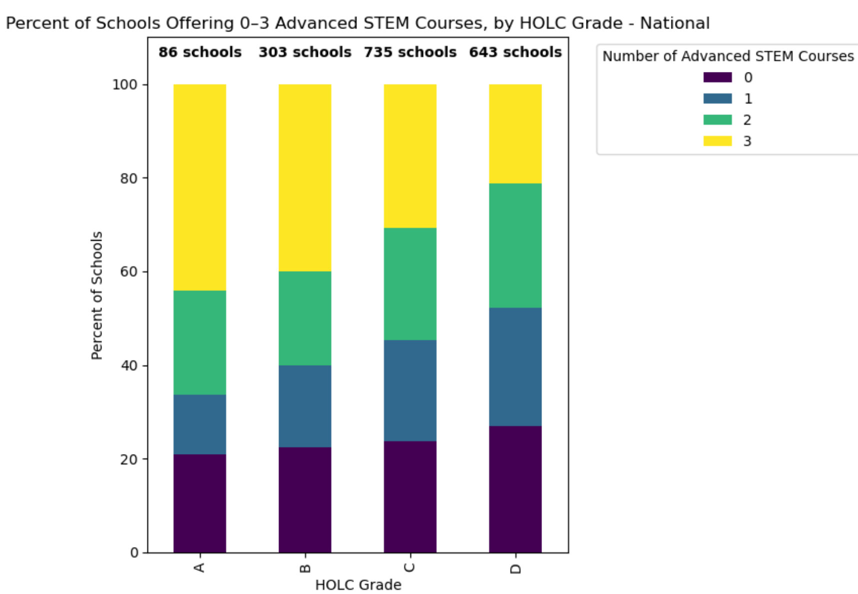

Figure 2. Percent Distribution of Schools Offering 0–3 Advanced STEM Courses, by HOLC Grade

Notes: This stacked bar chart presents the distribution of the number of advanced STEM subjects offered across four HOLC grades. Schools in A-rated neighborhoods are substantially more likely to offer all three STEM subjects, while schools in C- and D-rated areas are more likely to offer none. Sample sizes for each grade appear above the bars.

Table I provides the numeric distribution underlying the graph, showing a consistent decline in STEM opportunity as HOLC grade worsens.

Table I. Numeric Summary of Course Availability by HOLC Grade

HOLC Grade	Total Schools	0 Count	0 %	1 Count	1 %	2 Count	2 %	3 Count	3 %
A	86	18	20.9%	11	12.8%	19	22.1%	38	44.2%
B	303	68	22.4%	53	17.5%	61	20.1%	121	39.9%
C	735	175	23.8%	158	21.5%	176	23.9%	226	30.7%
D	643	173	26.9%	163	25.3%	171	26.6%	136	21.2%

A complementary perspective comes from examining the average number of courses offered in each subject area. Figure 3 plots the mean number of calculus, computer science, and physics courses by HOLC grade. The pattern again shows a smooth, monotonic decline from A to D for every subject. On average, A-rated neighborhoods offer the highest levels of advanced math and science—approximately 3.4 calculus classes, 5.6 computer science classes, and more than 8 physics classes. These averages fall sharply for lower-rated neighborhoods: D-rated areas typically offer only about 1 calculus class, 2.2 computer science classes, and 4.3 physics classes. Notably, the error bars across grades show little overlap, suggesting that these differences are both educationally meaningful and statistically precise.

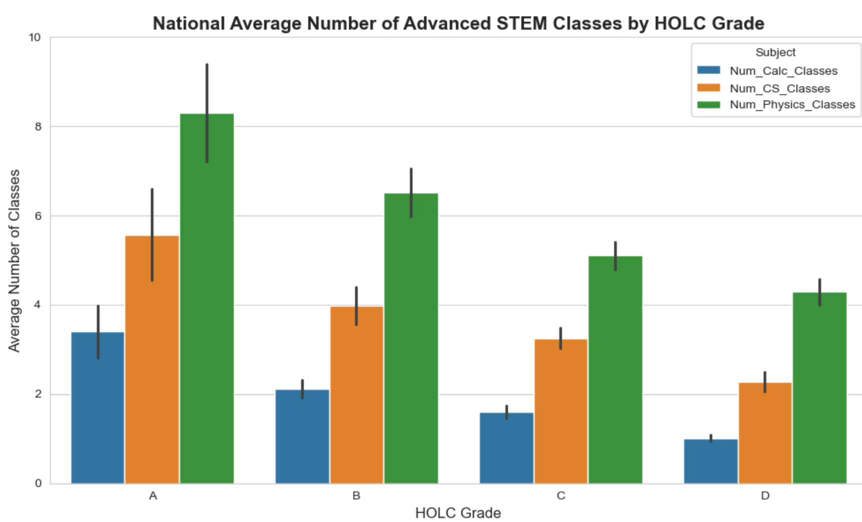

Figure 3. National Average Number of Advanced STEM Classes by HOLC Grade

Notes: This figure shows the mean number of advanced calculus, computer science, and physics classes offered by schools in each HOLC grade. Error bars represent standard errors. The decline in the number of classes offered from A to D highlights substantial reductions in the breadth of advanced STEM opportunities available to students in historically disadvantaged neighborhoods.

Together, Figures 1–3 present a consistent descriptive picture: historically redlined areas are less likely to offer any advanced STEM coursework, and when such courses are offered, they tend to be fewer in number across all STEM disciplines.

4.1.2 Regression Estimates for Any Advanced STEM Access

Table II presents linear probability model estimates for the probability a school offers at least one advanced STEM course. The first column uses a binary indicator for whether a school is located in a historically redlined (C/D) neighborhood. Schools in C/D zones are 10.5 percentage points less likely to offer an advanced STEM course than schools in A/B areas ($p \approx 0.051$). While marginally significant, this estimate is consistent in magnitude with the model-based predicted probabilities in Figure 1.

The categorical specification allows separate comparisons across all four HOLC grades. Relative to A-rated neighborhoods, B-rated areas show no difference, C-rated areas show a small negative difference, and D-rated areas show the largest gap (-0.152), albeit just shy of conventional statistical significance ($p = 0.124$). Across both specifications, magnet schools consistently display significantly higher STEM access ($p < 0.001$), while charter schools do not differ from traditional public schools.

Table II. Effect of HOLC Grade on Probability of Offering ≥1 Advanced STEM Course

Variable	Binary Redline (C/D)	HOLC Grade Categories
Redline (C/D)	**-0.105** (0.054)	—
HOLC B	—	0.010 (0.095)
HOLC C	—	-0.052 (0.088)
HOLC D	—	-0.152 (0.099)
Magnet School	0.218 (0.064) ***	0.238 (0.064) ***
Charter School	-0.080 (0.079)	-0.061 (0.081)
% Certified Teachers	—	-0.001 (0.002)
Title I School	—	0.147 (0.056) **
Intercept	0.771 (0.173) ***	0.783 (0.194) ***
N	1,767	1,767

p <.10, * p <.05, ** p <.01, *** p <.001

4.1.3 Regression Estimates for the Number of Advanced STEM Subjects Offered

Table III reports the OLS models predicting the number of advanced STEM subjects offered (0–3). These models reveal substantially stronger associations between HOLC grade and curricular breadth. Schools in C/D neighborhoods offer 6.7 fewer advanced STEM subjects on average than schools in A/B areas ($p = 0.004$). This is a large decline, particularly given the limited number of advanced STEM course types typically available.

The categorical specification again shows a monotonic gradient: compared to A-rated areas, B schools offer 3.1 fewer STEM subjects, C schools offer 5.9 fewer, and D schools offer a striking 12.5 fewer ($p < 0.001$). These differences closely mirror the descriptive patterns in Figure 3, where the steepest declines occur moving from "A" to "D" neighborhoods.

Table III. Effect of HOLC Grade on Number of Advanced STEM Subjects Offered

Variable	Binary Redline (C/D)	HOLC Grade Categories
Redline (C/D)	**-6.675** (2.290) **	—
HOLC B	—	-3.124 (3.462)
HOLC C	—	-5.874 (3.557)
HOLC D	—	**-12.474** (3.663) ***
Magnet School	3.267 (3.480)	4.644 (3.505)
Charter School	-11.718 (2.998) ***	-10.758 (2.989) ***
% Certified Teachers	-0.057 (0.086)	-0.072 (0.088)
Title I School	5.475 (2.734) *	5.794 (2.713) *
Intercept	23.512 (8.454) **	26.984 (9.246) **
N	1,767	1,767

p <.10, * p <.05, ** p <.01, *** p <.001

4.1.4 Summary of National Findings

Nationally, the legacy of HOLC redlining remains clearly visible in access to advanced STEM coursework. Across both extensive (any STEM) and intensive (number of STEM subjects) margins, lower HOLC grades are associated with worse opportunities—even when comparing schools located within 0.25 miles of one another on opposite sides of a historical boundary.

The probability of offering any advanced STEM course falls modestly from A to D, while the number of STEM subjects offered falls sharply, especially in formerly "D" areas. The descriptive evidence in Figures 1–3, combined with the regression estimates in Tables II and III, shows that redlining's long-term educational impacts operate not merely through whether schools offer STEM at all, but through the breadth and depth of STEM curricula—an important determinant of students' college readiness and long-term STEM career opportunities.

4.2 City-Level Analyses (Chicago, LA, Philadelphia, Detroit)

To complement the national analysis, I examine how the relationship between historical HOLC grades and advanced STEM course offerings appears within four large, historically redlined metropolitan areas: Chicago, Los Angeles, Philadelphia, and Detroit. These cities were selected because each contains at least three neighborhoods of every HOLC grade and each has substantial variation in school locations relative to HOLC boundaries. As in the national design, I restrict the analysis to high schools located within 0.25 miles of a historical redlining boundary to ensure that comparisons are made across locally similar areas. The goal of this section is not to compare cities to one another, but rather to evaluate whether the patterns observed nationally also hold within individual urban contexts, and to understand where and why deviations may occur.

4.2.1 Descriptive Patterns Within Cities

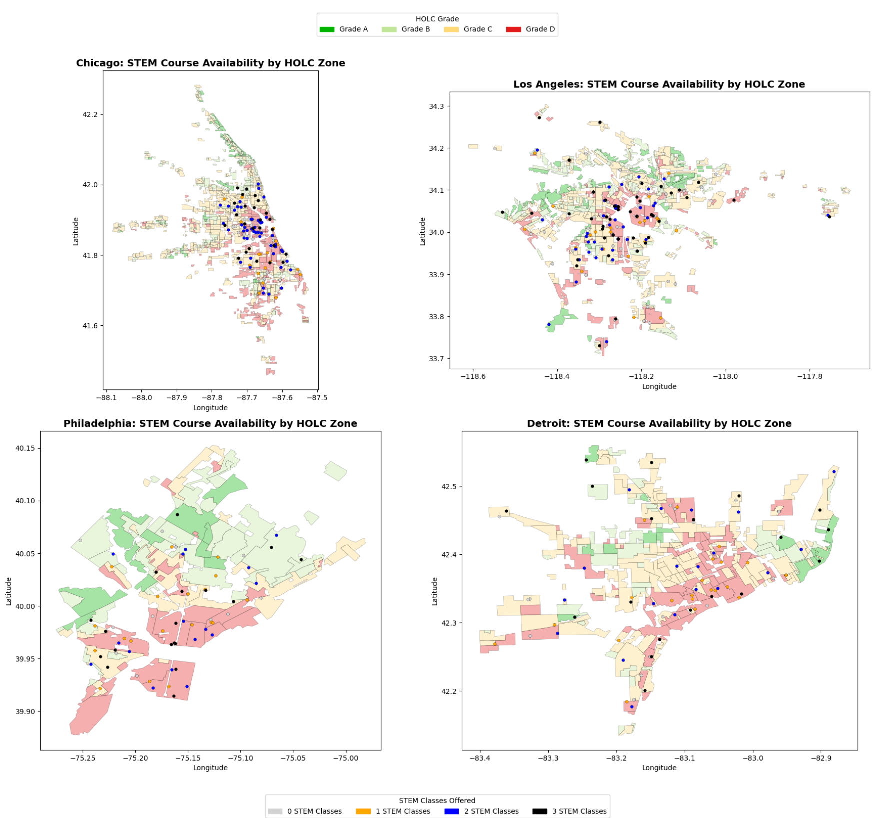

Figure 4. HOLC Neighborhoods and STEM Course Availability, Four Major Cities

Notes: Each panel maps historical HOLC zones (A–D) for Chicago, Los Angeles, Philadelphia, and Detroit. High schools are overlaid and shaded by the number of advanced STEM courses offered (0–3). Across cities, schools in A- and B-rated neighborhoods generally offer more advanced STEM coursework, while those in C- and D-rated areas often offer fewer options. Los Angeles shows a more diffuse pattern, reflecting local placement of magnet and specialized schools.

Across cities, descriptive visualizations show heterogeneous—but broadly consistent—relationships between HOLC grade and advanced STEM offerings. The 2×2 map in Figure 4 displays each city's HOLC zones with high schools overlaid and shaded by the number of advanced STEM courses they offer. In both Chicago and Detroit, the spatial pattern closely mirrors national expectations: schools in A- and B-rated neighborhoods cluster in areas with more advanced STEM options, while schools in C- and especially D-rated areas tend to offer fewer courses. Philadelphia exhibits a similar but less pronounced gradient, in part because fewer schools are located in A-rated neighborhoods within the 0.25-mile boundary sample. Los Angeles stands out as the least consistent with national patterns; schools offering multiple advanced STEM courses appear fairly dispersed, including in C- and D-rated areas.

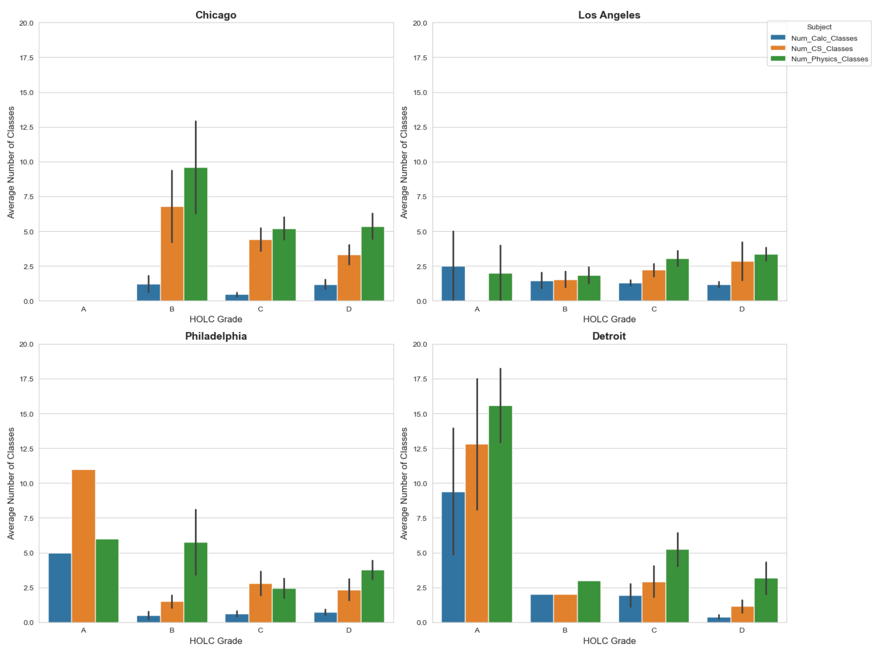

Figure 5. Average Number of Advanced STEM Courses by HOLC Grade, Four Major Cities

Notes: This 2×2 panel reports mean numbers of advanced calculus, computer science, and physics courses offered by high schools in each HOLC grade category (A–D). Error bars represent standard errors. Chicago display strong monotonic declines from A $\rightarrow D; PhiladelphiashowsmoderatedeclineswithmorenoiseduetosmallA-ratedsamplesizes; LosAngelesexhibitscomparativelyflatorreversedgradients, likelyreflectingitsdistinctschool-choiceinfrastructureandmagnetschoolgeography.$

A parallel 2×2 plot in Figure 5 shows the mean number of advanced calculus, computer science, and physics courses by HOLC grade for each city. Here again, Chicago and Detroit display a clear declining pattern from A to D, especially in physics and computer science. Philadelphia shows moderate declines, though some grades have few observations, which introduces volatility in the means. Los Angeles once again diverges: averages for C- and D-rated neighborhoods are similar to—or in some cases higher than—those in A- or B-rated areas. This contrasts sharply with the national pattern shown earlier in Figure 3, where declines from A to D are smooth and sizable.

These descriptive findings suggest that the national pattern is not simply an artifact of a few large cities. Instead, the broad trend of reduced STEM offerings in historically lower-rated neighborhoods appears in most—but not all—urban contexts. Los Angeles represents the primary outlier, and the regression results help clarify why.

4.2.2 Regression Estimates Within Cities

Table IV summarizes the binary redline effects for each city, showing the estimated difference between schools in historically redlined (C/D) versus non-redlined (A/B) areas in both (1) the probability of offering any advanced STEM course and (2) the total number of advanced STEM courses offered.

Table IV. City-Level Binary Redline Effects on STEM Access

City	Binary Redline Effect (Any STEM)	Binary Redline Effect (Total STEM)
Chicago	-0.173785	-6.05046
Detroit	-0.28288	-24.4881
LA	0.078797	2.42456
Philly	0.083938	-2.29009

Notes: This table summarizes binary regression estimates comparing schools in historically redlined (C/D) neighborhoods to those in higher-rated (A/B) neighborhoods across four major cities. The first column reports the effect of redlining on the probability that a school offers at least one advanced STEM course (Any STEM). The second column reports the effect on the total number of advanced STEM courses offered. Negative coefficients indicate reduced STEM access in C/D zones. Chicago and Detroit display large negative effects consistent with national patterns, Philadelphia shows smaller and imprecise effects, and Los Angeles exhibits positive coefficients, reflecting the city's unique distribution of magnet and specialized schools in lower-rated historical zones.

Across cities, Chicago and Detroit show strong negative associations between redlining and STEM access. In Chicago, schools in C/D neighborhoods are 17.4 percentage points less likely to offer any advanced STEM course, and they offer 6.05 fewer courses in total. Detroit displays even larger effects: a 28.3–percentage point reduction in the probability of offering any advanced STEM and a striking 24.5-course deficit in total offerings. These magnitudes exceed the national estimates and suggest that historical neighborhood ratings continue to strongly shape educational opportunity in cities where economic and demographic segregation remain especially pronounced.

Philadelphia's binary redline effects are small and statistically inconsistent in magnitude (-2.29 to +8.39), echoing the ambiguity in the descriptive plots. This is likely explained by the limited number of schools in A-rated neighborhoods within the boundary sample—many HOLC A areas in Philadelphia were historically smaller and more residential, resulting in fewer present-day high schools. As a result, estimates for A to D comparisons are noisier and less stable than in Chicago or Detroit.

Los Angeles is the only city where both coefficients point in the opposite direction of national patterns. Schools in historically redlined areas are estimated to be slightly more likely to offer any advanced STEM course (+7.9 percentage points) and to offer more STEM courses overall (+2.42). Importantly, this does not necessarily imply that redlining "reversed" in Los Angeles. Rather, it reflects two structural features of the city: (1) extensive postwar suburban expansion that altered the distribution of school types relative to HOLC boundaries, and (2) a concentration of magnet and specialized high schools in historically lower-rated central LA neighborhoods. These institutional dynamics mean that HOLC boundaries in Los Angeles align less cleanly with present-day school resources than in the more rigidly segregated Midwestern and Northeastern cities.

The categorical regression results (Table V) reinforce these patterns. Chicago and Detroit again show monotonic declines across B, C, and D categories for both AnySTEM and TotalSTEM outcomes, mirroring the national gradient. Philadelphia's coefficients fluctuate in sign but remain modest in magnitude. Los Angeles shows positive coefficients across all categories, consistent with the idea that local school placement and magnet-program geography weaken the historical relationship between redlining and STEM access.

Table V. City-Level Categorical HOLC Grade Effects on STEM Access

City	AnySTEM_B	AnySTEM_C	AnySTEM_D	TotalSTEM_B	TotalSTEM_C	TotalSTEM_D
Chicago	0.364748	0.165596	0.220373	3.12622	-3.36243	-2.41623
Detroit	-0.00498647	-0.251999	-0.317836	-30.9919	-27.2652	-32.1833
LA	0.186819	0.201986	0.287856	0.468041	2.47458	3.26122
Philly	-0.218171	-0.082414	-0.142491	-14.8718	-16.957	-16.0355

Notes: This table reports regression estimates comparing each HOLC grade (B, C, and D) to A-rated neighborhoods within each city. Columns 1–3 present the effects on the probability that a school offers at least one advanced STEM course (Any STEM). Columns 4–6 present the effects on the total number of advanced STEM courses offered. Chicago and Detroit show clear monotonic declines from B to C to D, aligning with national patterns of reduced STEM opportunity in lower-rated historical zones. Philadelphia exhibits modest and variable effects, largely due to limited A-rated coverage in the boundary sample. Los Angeles again departs from the national trend, displaying positive coefficients across categories, likely reflecting its concentrated magnet and specialized high school presence in historically lower-rated neighborhoods.

4.2.3 Comparison to National Patterns

Taken together, the city-level analyses demonstrate that the national results are not driven solely by one or two metropolitan areas. Chicago and Detroit closely replicate the national pattern: schools in historically redlined areas offer significantly fewer STEM classes and are less likely to offer any at all. Philadelphia shows muted effects due to small sample sizes in top-rated areas, but its qualitative direction aligns with the national trend. Los Angeles, by contrast, deviates from both the national pattern and the other cities—largely due to the city's distinct educational geography, including widespread magnet programs located disproportionately in lower-rated HOLC areas.

Overall, these results suggest that redlining's educational legacy is robust at a broad scale, yet its local manifestation varies depending on how historical boundaries intersect with postwar development, school-choice ecosystems, and district-level reforms. In cities with stable neighborhood structures (Chicago, Detroit), the HOLC gradient remains a powerful predictor of STEM access. In cities with significant postwar transformation (Los Angeles) or limited A-rated coverage (Philadelphia), the relationship becomes more diffuse. Nonetheless, even in these cases, descriptive patterns still show disparities in STEM depth across neighborhoods, consistent with broader structural inequalities.

5 Discussion

This paper provides new evidence that the legacy of historical redlining continues to shape access to advanced STEM coursework in American high schools. Using a boundary discontinuity design across 113 HOLC-mapped cities and a more detailed set of case studies in Chicago, Detroit, Philadelphia, and Los Angeles, the results demonstrate that schools located in historically lower-rated neighborhoods systematically offer fewer advanced STEM opportunities than schools in higher-rated areas located just across the same historical boundaries. While the magnitude of the effects varies across cities, the national pattern is robust: both the likelihood of offering any advanced STEM course and the total number of STEM subjects offered decline steadily from HOLC A $\rightarrow Dneighborhoods$.

The descriptive evidence makes these patterns especially clear. Nationally, the steepest differences emerge in the depth of course offerings, with A-rated areas offering far more calculus, computer science, and physics courses than D-rated areas. Importantly, these differences persist within narrow 0.25-mile boundary zones, where the physical environment, tax districts, and broader municipal services are otherwise quite similar. These patterns suggest that redlining's legacy continues to operate through long-run differences in neighborhood investment and school-level resource accumulation, even long after HOLC maps ceased to hold formal authority.

The city-level analyses provide further insight into how these national patterns manifest—not uniformly, but in ways shaped by local educational ecosystems. Chicago and Detroit both closely mirror the national gradient. These cities have long-standing housing segregation, persistent school funding disparities, and neighborhood infrastructures that remain strongly correlated with historical HOLC ratings. In these contexts, redlining's imprint appears directly in today's distribution of advanced STEM opportunities. Schools in C- and D-rated areas are less likely to offer any STEM coursework, and they offer substantially fewer classes overall—effects that are often larger in magnitude than the national estimates.

Philadelphia follows a similar directional trend, but with weaker and more volatile estimates. The city's boundary sample contains relatively few schools in A-rated neighborhoods, which limits statistical precision. Nonetheless, the descriptive maps and average-course plots still show reduced STEM depth in lower-rated areas. This pattern supports the idea that the relationship between redlining and STEM access is widespread, even if its strength varies based on local school density, district organization, and neighborhood development.

Los Angeles is the main exception. Its schools show little to no decline—and in some cases modest increases—in advanced STEM offerings when moving from A- to D-rated neighborhoods. This divergence does not contradict the national pattern but instead illustrates how local educational institutions can alter or weaken the influence of historical redlining. Los Angeles has a unique distribution of specialized, magnet, and STEM-focused high schools that are disproportionately located in formerly C- and D-rated areas of the city's central basin. In this context, present-day school placement reflects more recent district reforms rather than the spatial logic of the 1930s HOLC maps. The LA case underscores that the legacy of redlining interacts with the postwar evolution of urban school systems, and that contemporary policies can either reinforce—or partially override—historical patterns.

Together, the results point to three broader conclusions. First, redlining's educational legacy operates on both the extensive margin (whether a school offers any advanced STEM coursework) and the intensive margin (how many STEM subjects a school can support). The latter relationship is particularly strong and has important implications for STEM readiness and college trajectories. Second, while the national pattern is clear and consistent, cities differ in how strongly historical boundaries map onto present-day educational inequality—reflecting differences in school district reforms, program placement, demographic shifts, and urban development. Third, the strongest city-level effects appear in places where neighborhood disadvantage remained closely tied to mid-century patterns of segregation, suggesting that redlining's impact is most persistent where structural inequalities have compounded over time.

Although this study does not directly evaluate policy interventions, the findings point toward several areas where targeted action may help narrow opportunity gaps. Briefly, districts may consider prioritizing advanced STEM expansion in lower-rated HOLC areas, reviewing magnet and specialty program placement for equity implications, and strengthening teacher training pipelines for schools serving historically disadvantaged neighborhoods. These strategies are not substitutes for broader structural reforms, but they may help mitigate some of the persistent inequalities uncovered in this analysis.

Overall, the results highlight that the geography of advanced educational opportunity in the United States is still deeply connected to its historical landscape. Understanding how these patterns emerged, and why they persist or weaken across different local contexts, is essential for designing policies that meaningfully expand STEM access for students in all communities.

6 Conclusion

This paper examines the long-run relationship between historical redlining and contemporary access to advanced STEM coursework in U.S. public high schools. Using a boundary discontinuity design across 113 cities and detailed case studies of Chicago, Los Angeles, Philadelphia, and Detroit, the analysis provides consistent evidence that the educational landscape inherited from the 1930s HOLC maps continues to shape students' opportunities to pursue rigorous STEM preparation today.

Across the national sample, STEM access declines steadily from HOLC A $\rightarrow Dneighborhoods.Schoolsinhistoricallylower-ratedareasarenotonlylesslikelytoofferanyadvancedSTEMcoursework, buta$ $leveldisadvantageindependentofbroadercitywideconditions.$

The city-level analyses reinforce, refine, and contextualize these national trends. In Chicago and Detroit, the effects of redlining are especially pronounced, with large deficits in both the probability of offering any STEM course and the total number of courses offered. Philadelphia shows a similar directional pattern with somewhat less precision, reflecting its smaller number of A-rated schools in the boundary sample. Los Angeles stands apart from the expected gradient, likely due to its unique distribution of magnet and specialized high schools, illustrating that contemporary educational policies and urban development can either reinforce or weaken historical spatial patterns. Together, these cases demonstrate that while the national relationship between redlining and STEM access is strong, its local manifestations depend on how school systems and cities have evolved in the decades since the HOLC maps were created.

Although this study does not attempt to quantify the full causal effect of redlining or evaluate specific policy interventions, the findings suggest meaningful avenues for expanding educational opportunity. Targeted investments in advanced STEM programs, revisiting the placement of magnet and specialty schools, and strengthening teacher pipelines in historically disadvantaged areas may help mitigate some of the persistent disparities identified here. More broadly, the results emphasize the need to consider how historical structures continue to shape educational environments and how modern policy can either counteract or reproduce those legacies.

Redlining may be nearly a century old, but its educational imprint remains visible. Understanding how these long-standing patterns continue to affect students' access to advanced STEM preparation is essential for designing policies that expand opportunity and promote equity across American schools.

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7 Appendix

Here I want to have some additional regressions I do not want to put in the main body.

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