

# LANGUAGE MINORITY STUDENTS' MATHEMATICS ACHIEVEMENT IN URBAN SCHOOLS: COURSEWORK, RACE-ETHNICITY, AND ENGLISH-LANGUAGE PROFICIENCY

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## Abstract:

The mathematics performance data from 12,738 high school students were examined to determine the relationship between students' racial-ethnic and linguistic background, participation in higher level mathematics courses, and performance on a norm-referenced measure of achievement, explicitly accounting for important urban school context indicators. Using hierarchical linear models (HLM), researchers analyzed the effects associated with language minority students' mathematics achievement in urban schools. Findings suggest that urban high school students' participation in higher level mathematics courses may ameliorate pervasive patterns of racial-ethnic and linguistic minority disparities in achievement.

**Keywords:** urban schools; mathematics achievement; coursetaking; English-language learners

## Introduction

The Common Core State Standards (CCSS) in English/language arts and mathematics were developed from previous state-created content standards and their primary purpose was to outline quality indicators of mathematics teaching and learning that are consistent across U.S. states. In addition to delineating the mathematical content students should learn in K-12 schools, CCSS also provide guidelines for how teachers should deliver mathematics instruction. Instructional processes identified by the National Council of Teacher of Mathematics (2000; 2003) and National Research Council (2001) are synthesized by CCSS as standards for mathematical practice (CCSS-MP). CCSS-MP expectations include: (1) sense-making and perseverance, (2) abstract quantitative reasoning, (3) argumentation and reasoning, (4) modeling, (5) resource selection, (6) communicative appropriateness, (7) structural awareness and (8) patterns of regularity (NGACBP & CCSSO, 2010, pp. 6-8). Combined, CCSS and CCSS-MP are important policy shifts in mathematics education that influence pedagogical practices and trends in achievement.

Shifts in educational policy that modify instructional demands and the knowledge and skills students should learn in mathematics require equity-oriented considerations, particularly for students that have consistently underachieved in mathematics such as Language Minority (LM) students in urban schools. Both CCSS and CCSS-MP were authored in alignment with the No Child Left Behind Act (NCLB), a federal policy that prioritized national standards and assessment. CCSS policies are distinctive from NCLB policies in emphasizing college readiness curricula, instead of high school completion. Considering the historical disparities in achievement and high school completion percentages disproportionately associated with racial-ethnic and language minority students in urban schools, does CCSS' emphasis on college readiness exacerbate achievement disparities? Furthermore, as the accountability focus shifts from schools to teachers under CCSS, what structural supports will be required for learning mathematics, and what pedagogical practices will be required for LM students in urban schools?

This study explores the relationship between students' demographic background, participation in high level mathematics courses, and achievement outcomes and explicitly considers the intersection of language and mathematics in urban school contexts. The implementation of CCSS in urban schools requires that mathematics teachers negotiate familiar curricular concerns while adapting to conceptual disciplinary shifts, such as the integration of language, literacy and mathematics. CCSS learning expectations include mathematics knowledge as well as literacy skills. This simultaneous learning demand has disproportionate effects on the achievement of LMs with varying English language proficiency levels (Aguirre & Bunch, 2012), particularly in high school mathematics (Capraro, Capraro, & Lewis, 2013; Mosqueda & Maldonado, 2013a; 2013b). The intensification of content and language demands requires careful consideration of educational policies that promote all students' participation in higher level mathematics courses and the provision of pedagogical practices that promote the simultaneous learning of English, academic content, and the language and literacy demands specific to mathematics (van Lier & Walqui, 2012; Wong Fillmore, 2007).

Furthermore, the high school mathematical content standards also call for the importance of the mathematical preparation of students for college and career readiness. While the content standards do not provide a mandate for the specific sequence of courses high school students should take (CCSS, 2010), prior research has documented the importance of mathematics coursework and its relation to improved performance on mathematics assessments, high school graduation rates, and college attendance (Adelman, 1999; 2006). As national dialogue moves in the direction of defining college readiness, how will LMs in secondary schools be impacted by the implementation of college readiness expectations in mathematical content and the language and literacy learning demands established by CCSS? In particular, we must consider the educational equity implications of teaching and learning in urban schools, where students with low-income, racial-ethnic and language minority backgrounds have historically been vulnerable to the deleterious consequences of school failure.

## Assessment and Achievement

Assessment measures of students' failure and success in school inform the relationship between educational policy and instructional practices in the U.S. Achievement measures provide "information about current status and progress of student achievement and quality of schooling," and often serve as a focal point for "reforming educational practices" (Miller, Linn, & Gronlund, 2009, p. 3). Since 1965, the Elementary and Secondary Education Act (ESEA) measures students' national achievement to document "disparities in educational opportunities and in student performance" (p. 4). In 2001, legislators reauthorized ESEA as NCLB and achievement measures became high-stakes accountability indicators. For schools, high-stakes achievement measures determine economic rewards and sanctions (e.g., programmatic funding, teacher reassignment, school reconstitution); for students, high-stakes achievement measures determine curricular experiences (e.g., academic track placement, grade promotion, high school graduation) (Heubert & Hauser, 1999).

Results from the National Assessment of Educational Progress (NAEP) mathematics assessment measure students' knowledge, skills, and problem solving in the following mathematical content: (a) number properties and operation, (b) measurement, (c) geometry, (d) data analysis, statistics, and probability, and (e) algebra (NCES, 2017). Average scale scores for twelfth-grade students in NAEP mathematics reveal consistent disparities associated with students' gender, race-ethnicity (Capraro et al., 2009; Capraro, Capraro, & Lewis, 2013), and also the English-language proficiency level of LM students (Duran, 2008; Martiniello, 2008; Mosqueda et al., 2016; Solano-Flores, 2008, 2011; Tellez & Mosqueda, 2015). Our research analyzes such mathematics achievement trends from an equity perspective. Gutiérrez (2007) described equity in mathematics teaching and learning as an "*inability to predict*" student outcomes based *solely* upon cultural markers" and calls for the studying of systematic trends (p. 42, *emphases original*). We are interested in learning about the policy structures and pedagogical practices that address the predictable achievement patterns associated with students' demographic background and schools' location.

### Higher Level Mathematics Courses

Although CCSS provided disclaimers, such as: "the standards themselves do not dictate curriculum, pedagogy, or delivery of content" and "these standards do not mandate the sequence of high school course," CCSS is designed to align learning with college readiness (p. 84). Research has shown that completing high school coursework beyond Algebra II (e.g., trigonometry, pre-calculus, and calculus) is associated with higher achievement on standardized tests (Callahan, 2005; Mosqueda & Maldonado, 2013b) as well as likelihood for college matriculation (Adelman, 2006). Given the importance of participating in higher level mathematics courses in high school, research must also consider educators' preparedness for implementing CCSS for LM students, particularly those in the process of developing English-language proficiency (Callahan, Wilkinson, & Mueller, 2010; Lee, Quinn & Valdes, 2013; Téllez, Moschkovitch & Civil, 2013; van Lier & Walqui, 2012). Mosqueda and Maldonado (2013a) defined equitable curricular pathways as "a measure of mathematical curriculum that consists of both the quantity and quality of mathematics courses available to, and taken by, students as well as the content-area expertise of students' mathematics teachers." (pp. 205-206).

CCSS developed traditional and integrated course pathways in mathematics for students' college readiness (ACT, 2008). The traditional pathway suggested the following course sequence: Algebra I, Geometry, and Algebra II. The integrated pathway suggested Mathematics I, Mathematics II, and Mathematics III as an appropriate course sequence. CCSS defined fourth, or additional, courses as "higher level mathematics," which include "precalculus, calculus, advanced statistics, discrete mathematics, and advanced quantitative reasoning" (NGACBP & CCSSO, 2010, p. 4). Participating in higher level mathematics courses is associated with readiness for college algebra. ACT and Education Trust (2004) have shown that just 13 percent of high school students that do not participate in higher level mathematics are prepared for college algebra, drastically lower than the 75 percent of students that do participate in higher level mathematics and are prepared for college algebra. Considering the association of not participating in credit-bearing courses in college and undergraduate persistence, preparation for college algebra is critical. Our equity perspective considers the policy structure of CCSS contradictory. While CCSS prioritizes college readiness curricula, higher level mathematics courses are simultaneously framed as optional. College readiness has been defined as the level of preparation a student needs in order to enroll and succeed—without remediation—in a credit-bearing general education course at a postsecondary institution that offers a baccalaureate degree or transfers to a baccalaureate program (Conley, 2007). Particularly in mathematics, educational policymakers must focus on structuring equitable learning conditions so that all students may be prepared to experience pathways that exceed high school graduation requirements and include higher level mathematics.

### Urban School Context Indicators

As CCSS prioritizes curricula that promotes college readiness, the importance of a school's urban school context should not be overlooked. We are mindful that predictable student achievement patterns are associated with schools' designation as either urban, suburban, or rural. Such designations are often associated with metropolitan statistical areas as classified by U.S. Census data that ascribe urbanicity to metropolitan communities comprised of more than 50,000 persons. Urban schools in the U.S. often serve high percentages of low-income, racial-ethnic and linguistic minority students (Lippman, Burns, & McArthur, 1996). Schools in urban areas typically face the greatest challenges and most acute problems. Effective responses to urban school complexities is complicated by the concentration of poverty, lack of access to adequate social services, crime and racial-ethnic segregation, which taken together, all have an effect on the educational quality of schools and students' opportunities to learn (Conchas, 2006; 2016; Conchas & Vigil, 2012; Noguera, 1996; 2003).

Research shows that income and racial-ethnic segregation of students in urban schools is associated with lower student achievement (Orfield & Lee, 2007). Rumberger and Palardy (2005) examined the effects of income and racial-ethnic segregation in urban schools and found that the percentage of low-income students was more influential on achievement than the percentage of racial-ethnic minority students. Such findings suggest that urban schools with high percentages of low-income students exemplify contextual conditions for improving policy structures and pedagogical practices. While income and racial-ethnic segregation are influential moderators of students' achievement, the linguistic realities of students in urban schools also requires attention. Gándara & Orfield (2010) found that segregation of students developing English-language proficiency is associated with both disparities in achievement measures as well as socioemotional development. Corroborating findings by Gifford and Valdés (2006) argued that the segregation of language minority students compounds the economic and racial-ethnic segregation of students in urban schools. These studies of *de facto* segregational patterns by students' socioeconomic, racial-ethnic and language background call for more nuanced perspectives of urbanicity (Gándara & Orfield, 2010; Gifford & Valdés, 2006).

Urban schools must be mindful of the implications of segregational patterns on achievement as well as attentive to the attenuating effects of students' participation in higher level mathematics courses. Research shows that access to college readiness curricula, particularly in mathematics, is limited in urban schools with high percentages of low-income, racial-ethnic, and language minority students (Oakes et al., 2004). Moreover, students in urban

schools may experience inequitable access to teachers with professional preparation in mathematics as well as adequate instructional resources (Gándara & Contreras, 2009; Olsen, 2010). In order to minimize challenges and maximize opportunities in urban schools, policy and practices must approach mathematics teaching and learning as a right (Moses & Cobb, Mosqueda & Maldonado, 2013a; Perry, Steele, & Hilliard II, 2003; Rousseau Anderson & Tate, 2008; Tate, 2001).

## Opportunities to Learn Mathematics and English Simultaneously

Analyses of the racial-ethnic composition of students in urban schools show that percentages of Asian and Latina/o students have surpassed percentages of Black students (Frankenberg, 2009; Orfield & Lee, 2005). Such transformation in student enrollment patterns requires an explicit consideration of the relationship between English-language background and mathematics achievement. LM students, who speak a language other than English at home, are more likely to be low-income and enroll in urban schools (Abedi & Gándara, 2006; Gándara & Contreras, 2009; Ruiz-de-Velasco & Fix, 2000). In addition, researchers persistently identified LMs' mathematics achievement as disparate from non-LMs (Abedi, 2004; Mosqueda, 2010). How educational policies and instructional practices are structured is critical to supporting LMs in urban schools. Ruiz (1984) proposed three orientations for approaching students' linguistic diversity: (a) as problems to be resolved, (b) as rights to be protected, and (c) as resources to be valued. Urban schools that do not regard students' linguistic diversity as rights to be protected and resources to be valued will prioritize LMs' English-language acquisition at the expense of participation in higher level mathematics courses. Considering the consequences of inequitable access to college readiness curricula, urban schools require the provision of policy structures and pedagogical practices that value the simultaneous learning of mathematics and English as a right (Mosqueda & Maldonado, 2013a).

Contemporary mathematics educators' preparedness requires pedagogical content knowledge in mathematics as well as pedagogical language knowledge (Galguera, 2011; Bunch, 2013). As national standards, CCSS calls for developing students' knowledge and skills in mathematics and language simultaneously. The increased attention to language demands in mathematics teaching and learning requires research that analyzes how mathematics content knowledge and English-language background is interconnected, and explains the interactive effects of de facto segregation patterns in urban schools. This study is guided by the following question: Does racial-ethnic and English-language background influence the relationship between participation in higher level mathematics and achievement of high school students in urban schools?

## Method

A probability sample of high school students in 12th grade was analyzed from the Education Longitudinal Study (ELS: 2002), a nationally representative dataset created by the National Center for Education Statistics (Ingels, Pratt, Rogers, Siegel & Stutts, 2004). More recent national datasets, such as HSLS:2009, do not include achievement data for 12<sup>th</sup> grade students nor students' fluency in speaking, understanding, reading, and writing in English. The complete ELS:2002 sample includes 15,362 students from 752 schools and includes mathematics achievement information as well as student, family, teacher and school data. The weighted subsample in our study included all Asian, Black, Latina/o, and White students that completed the 12<sup>th</sup> grade mathematics assessment, totaling 12,738 students from 748 schools. Our sample size provided explanatory power to detect small effects at the typical levels of statistical significance (Light, Singer, & Willett, 1990). Our analysis employed hierarchical level models, with students nested in schools, to examine the relationships among participation in higher level mathematics courses, schools' urbanicity, students' racial-ethnic and linguistic background, and high school mathematics achievement.

## Variables in the Models

**Outcome Variable.** We used the mathematics achievement measure of twelfth-grade students relative to the population of high school seniors in 2004 as the outcome variable ( $F1MSTD_{ij}$ ).  $F1MSTD_{ij}$  is an IRT (Item Response Theory) scaled score recoded from  $F1TXMSTD$  for each student  $i$  in school  $j$  (Ingels et al., 2004). We used these IRT scaled scores as our outcome variable due to the accessible interpretations of predictor variables' influence on achievement. A one-point difference associated with the outcome variable equals one item correct on the ELS assessment. Coherent with NAEP mathematics assessment measures, the ELS:2002 mathematics assessment contained test items in: (a) arithmetic, (b) algebra, (c) geometry, (d) data probability, and (e) advanced topics. ELS:2002 scores were standardized to a mean of 50 and a standard deviation of 10. The mean mathematics scores for the students in our study was 50.72 with a standard deviation of 10.12, and a distribution range from 19.82 to 79.85. Appendix 1 displays detailed descriptions of all the variables in this study.

**Question Predictors.** One predictor variable in this study is the number of college readiness mathematics courses that students participated in by their senior year of high school ( $F1HIMTHR_{ij}$ ). This variable is structured by ELS: 2002 as a composite that communicates students' years of mathematics coursework (i.e., 0 = no math taken, 1 = Pre-Algebra or basic math, 2 = Algebra I, 3 = Geometry, 4 = Algebra II, and 5 = Trigonometry, Pre-calculus, or Calculus). Another predictor variable is the binary  $LM_{ij}$ , which we used to code LM and non-LM students (1 = LM, 0 = non-LM). We used information from the item that asked students, "Is English your native language (the first language you learned to speak when you were a child)" ( $F1STLANG$ ) to construct the  $LM$  variable (Ingels et al., 2004). 15 percent of students reported that English was not their native language and these students were coded as LMs. Moreover, we created the cross-product  $LM_{ij} * E\_PRF\_LM_{ij}$  to code LMs' degree of English-language proficiency (ELP). This weighted cross-product composite ranges from 3 to 8 (low to high) and is based on each student's response to four ordinal dimensions of self-reported English proficiency that include how well students: "understand spoken English," "speak English," "read English," and "write English." For each of these dimensions of English proficiency, students provided one of following ordinal responses: "Very well," "Well," "Not well," or "Not at all." The principal components analysis routine in STATA yielded the following weighted composite equation:  $ENG\_PROF = .486*UNDERSTAND + .511*SPEAK + .510*READ + .492*WRITE$ . This single construct of English proficiency captured 68 percent of the variance in the four English proficiency subscales. These estimates are consistent with prior studies that have validated the reliability of these measures of students' English proficiency (Portes & Rumbaut, 2001). Appendix 2 displays descriptive statistics of our analytic sample.

**Control Predictors.** To account for the influence of students' demographic background and schools' location, as well as account for issues associated with selectivity bias, our hierarchical models included various control predictors. Our controls included student-level (level 1) socioeconomic status as a standardized continuous composite, gender, and race-ethnicity. At the school-level (level 2), our controls included (a) urbanicity, (b) percentages of low-income, racial-ethnic and linguistic minority students, (c) percentage of students participating in college readiness curricula, and (d) percentage of certified teachers. Our hierarchical models employed appropriate ELS student-level and school-level weights (Raudenbush & Bryk, 2002).

## Analytic Strategy

Appendix 3 displays the three nested fitted models we computed for 12<sup>th</sup> grade measures of mathematics achievement. Our first model is an unconditional random effects ANOVA that does not include any independent (i.e., control) predictors. In our first model, F1MSTD<sub>ij</sub> is analyzed as a function of the intercept ( $b_0$ ) which represents the institutional average of each student's twelfth grade mathematics score, a random effect that is unique to each individual ( $r_{ij}$ ), and a random effect that is unique to each school ( $u_j$ ): F1MSTD =  $b_0 + (r_{ij} + u_j)$ . This model also provides intraclass correlation ( $\rho$ ) information regarding the proportion of variance in the achievement measure that is attributable to between-school differences ( $\tau_{00}$ ) and within-school ( $\sigma^2$ ) differences, as calculated by the following formula:  $\rho = \tau_{00} / (\tau_{00} + \sigma^2)$ . Intraclass correlation data show the appropriateness of a hierarchical analytic strategy with model 1 attributing 20.4 percent of the variance in students' mathematics achievement to between-school differences and 73.5 percent of the variance to within-school differences.

Our second model in the analysis contains the main effects of student- and school-level control variables, such as schools' location and students' race-ethnicity as well as participation in higher-level mathematics courses. The fitted multilevel regression models corresponding to our second model were:

$$\begin{aligned} \text{F1MSTD}_{ij} = & b_0 + b_1 \text{FEMALE}_{ij} + b_2 \text{SESF1}_{ij} + b_3 \text{MT\_CERTR}_{ij} + b_4 \text{MT\_MJRIR}_{ij} \\ & + b_5 \text{F1HIMTHR}_{ij} + b_6 \text{LATINA}_{ij} + b_7 \text{BLACK}_{ij} + b_8 \text{ASIAN}_{ij} + b_9 \text{PUBLIC}_j + \\ & b_{10} \text{URBAN}_j + b_{11} \text{SCHOOLSES}_j + b_{12} \text{PCT\_LEP}_j + b_{13} \text{PCT\_COLTRK}_j \\ & + b_{14} \text{PCT\_CREDT}_j + g_1 Z_{ij} + g_2 Z_j + (r_{ij} + u_j). \end{aligned} \quad (1)$$

Our third model analyzed the effects of LMs' English-language background and participation in higher level mathematics courses on 12<sup>th</sup> grade measures of achievement. The fitted multilevel regression models corresponding to our third model were:

$$\begin{aligned} \text{F1MSTD}_{ij} = & b_0 + b_1 \text{FEMALE}_{ij} + b_2 \text{SESF1}_{ij} + b_3 \text{MT\_CERTR}_{ij} + b_4 \text{MT\_MJRIR}_{ij} \\ & + b_5 \text{F1HIMTHR}_{ij} + b_6 \text{LATINX}_{ij} + b_7 \text{BLACK}_{ij} + b_8 \text{ASIAN}_{ij} + b_9 \text{LM}_{ij} + \\ & b_{10} \text{E\_PRF\_LM}_{ij} + b_{11} \text{PUBLIC}_j + b_{12} \text{URBAN}_j + b_{13} \text{SCHOOLSES}_j + b_{14} \text{PCT\_LEP}_j + b_{15} \text{PCT\_COLTRK}_j + b_{16} \text{PCT\_CREDT}_j + b_{17} \text{LATINA}_{ij} \cdot \text{LM}_{ij} \\ & + \text{E\_PRF\_LM}_{ij} \\ & + b_{18} \text{ASIAN}_{ij} \cdot \text{LM}_{ij} + \text{E\_PRF\_LM}_{ij} + g_1 Z_{ij} + g_2 Z_j + (r_{ij} + u_j). \end{aligned} \quad (2)$$

## Results

After verifying the normal distribution of outcome values using histograms and stem-and-leaf plots and residual values using predicted probability plots, as well as ensuring collinearity statistics did not exceed variance inflation factors of 3, we examined the relationship between students' racial-ethnic and linguistic background, participation in higher level mathematics courses, and 12<sup>th</sup> grade mathematics achievement in urban schools using multiple linear regression analyses. Model 1 showed that the average mathematics achievement in the population of all 12<sup>th</sup> grade students is 49.98. In Model 2, we found statistically significant relationships between 12<sup>th</sup> grade mathematics achievement, students' race-ethnicity, and participation in higher level mathematics, accounting for student-level as well as school-level controls. The effects between White students (the omitted category) and Asian students ( $\beta = 1.03, p > .05$ ) were not significant. Relative to White students, both Black students ( $\beta = -4.60, p < .001$ ) and Latina/o students ( $\beta = -2.52, p < .001$ ) had statistically significant lower mathematics scores. On average, Black students scored more than 4.5 points lower than White students, a difference of 45% of a standard deviation; and Latina/o students scored 2.5 points lower than White students, a difference of 25% of a standard deviation.

In addition to students' racial-ethnic background, results revealed students' socioeconomic status had a positive effect on mathematics outcomes. A one-unit (i.e., standard deviation) positive difference in socioeconomic status as coded by ELS:02 was associated with over a 2-point increment change on the mathematics outcome, ( $\beta = 2.34, p < .001$ ), a difference of over 20% of a standard deviation. Females' scores were near 1.5 points lower than the scores of males ( $\beta = -1.70, p < .001$ ), a difference of 15% of a standard deviation, on average.

Model 2 also communicates the interactive effect of LM status and students' English-language proficiency (ELP), as well as participation in higher level mathematics courses on the ELS: 2002 mathematics assessment. Average scale scores of LMs' with lower levels of ELP were below the aggregate scores of their LM peers with higher levels of ELP. In the aggregate, LMs' scores were 2-points lower than scores by non-LMs ( $\beta = -2.13, p < .001$ ), and for every one-unit positive difference in ELP an association of nearly one-quarter point positive difference was evident ( $\beta = 0.24, p < .05$ ), all other predictors being equal. Such differential effect is associated with one-fortieth of a standard deviation *for every unit change in ELP*. Combined, the interactive effects of ELP and LM status reveal the heterogeneity in LMs' measures of mathematics achievement. LMs at the lowest level of ELP, on average, score more than one and one-half points (1.72) below the mean achievement of non-LMs, a difference totaling more than 15% of a standard deviation and differ by one-quarter point for every unit change in ELP.

Additional statistically significant results in Model 2 included measures of mathematics teachers' preparation. Binary measures indicating whether or

not mathematics teachers held an undergraduate degree in a math-related field ( $\beta = 1.01, p < .001$ ) and whether or not teachers had completed their certification/credential ( $\beta = 1.17, p < .001$ ) were associated with a combined difference of 20% of a standard deviation. When the aforementioned student and teacher characteristics are considered in concert, the effects of whether or not a school is public ( $\beta = -0.87, p > .1$ ) or urban ( $\beta = -0.76, p > .1$ ) are not statistically significant. This model shows that the percentage of low-income students ( $\beta = -1.06, p < .001$ ) as well as the percentage of students participating in college readiness curricula ( $\beta = 0.31, p < .001$ ) are statistically significant predictors of students' mathematics achievement.

Finally, results from Model 2 showed that students' participation in advanced level mathematics courses are another important predictor of mathematics achievement, even after accounting for students' socioeconomic, racial-ethnic, and language background, as well as school-level controls. An association exists between *each* mathematics course in the college readiness sequence taken by individual students and a 4-point positive difference in mathematics scores ( $\beta = 4.01, p < .001$ ), a relative change of 40% of a standard deviation per course, on average. This model shows the critical importance of students' participation in four years of mathematics courses with college readiness curricula, particularly for Black and Latina/o students and LMs.

In Model 3, we found statistically significant relationships in the interactive effect of LM status, ELP, and students' racial-ethnic background. In Model 3, we analyzed three-way interactions between students' racial-ethnic background for Asian and Latina/o students (sample sizes were too small for Black and White LMs), LM status, and ELP, in relation to participation in higher level mathematics courses and measures of achievement at the end of twelfth grade. Results suggested that the relationship between students' English-language background and mathematics achievement is mediated by students' racial-ethnic background. Average scale scores from Model 3 showed that Asian LMs with low ELP were comparable to Asian LMs with high ELP, all other predictors being equal. On average, Asian LMs scored about one and one half-points below ( $\beta = -1.67, p < .01$ ) their White and Asian non-LM peers and their predicted achievement was associated with a positive .015 difference for every unit difference in the ELP composite (i.e., range minimum=3, range maximum=8). In contrast, Latina/o LMs scored about six points below ( $\beta = -5.84, p < .01$ ) their White and non-LM peers. Such scores were not only far lower compared to those of Asian LMs, but the disparities between Latina/o LMs with low ELP and those with high ELP were far more pronounced. For Latina/o LMs, every unit difference in ELP was associated with a .74 difference of points on the mathematics achievement. Model 3 estimates showed that the scores of Latina/o LMs with high ELP were comparable to the scores of Latina/o non-LMs; however, the average scale scores of Latina/o LMs with low ELP classified their subgroup as the most in need of equitable policy structures and pedagogical practices.

## Discussion

We analyzed the relationship between students' racial-ethnic and language background, participation in higher level mathematics courses, and mathematics achievement in urban high schools. Additionally, we examined the interactive relationship between LMs' racial-ethnic background and heterogeneity of ELP. Our findings revealed that schools' designation as either urban, suburban, or rural was not associated with students' mathematics achievement; however, we found relationships between schools' percentage of low-income students, schools' percentage of students participating in college readiness curricula, and student's scaled scores. Our data were consistent with prior research that associates students' achievement with socioeconomic composition of schools (Rumberger & Palardy, 2005; Orfield & Lee, 2005). Our findings suggest that urban schools with higher percentages of low-income students require the most support in structuring equitable policies and practices for mathematics teaching and learning. Our study also controlled for schools' percentage of LMs and the percentage of credentialed teachers in each school; however, these characteristics were not associated with students' mathematics achievement. These findings revealed that the percentages of low-income students in urban schools may be a helpful indicator to allocate the distribution of instructional resources in metropolitan areas.

Results from this study also suggest that participating in higher level mathematics is beneficial for all students, especially those enrolled in urban schools with high percentages of low-income students (Oakes et al., 2004). Our data reveal that students enrolled in urban schools with a student composition of 90 percent or more from low-income backgrounds are likely to underperform in mathematics achievement by 10 points on the ELS: 2002 mathematics assessment for 12<sup>th</sup> grade students, which nearly totals one standard deviation ( $\beta = -9.09, p < .001$ ). However, students that participate in four years of college readiness mathematics courses attenuate and improve upon this effect by one and one-half of a standard deviation ( $\beta = 16.04, p < .001$ ). Furthermore, the percentage of urban school students that participate in college preparatory curricula is also associated with students' higher mathematics achievement. Our analyses show that schools with a student composition of 90 percent or more participating in college readiness curricula were associated with a positive effect on students' mathematics achievement ( $\beta = 2.7, p < .001$ ), a difference of almost 30 percent of a standard deviation.

Our findings also reveal a nuanced relationship of students' racial-ethnic and linguistic background and mathematics achievement. Wilkins and the Educational Trust (2006) found that the average mathematical achievement of twelfth-grade Black and Latina/o students was comparable to the average mathematical achievement of eighth-grade White students. Our data were consistent with such racial-ethnic disparities in achievement. On average, both Black students and Latina/o students had statistically significantly lower mathematics scores, relative to White and Asian students. To improve upon such racial-ethnic disparities, our results suggest that Black and Latina/o students would benefit from participation in four years of college readiness courses in mathematics.

Findings from this study are also consistent with prior research that associated LM status and low levels of ELP with mathematics achievement (Callahan, 2005; Mosqueda & Maldonado, 2013a). Our data demonstrate achievement disparities in relation to students' LM status and degree of ELP. Both Asian LMs and Latina/o LMs with low ELP underperform on mathematics achievement relative to their co-ethnics with high ELP. However, Asian LMs outperform Black students, Latina/o LMs, and Latina/o non-LMs. Our results suggest that the achievement disparities of Latina/o LMs with low ELP are dramatically pronounced and call for substantial instructional support. Urban schools with high percentages of Latina/o LMs would benefit from supporting the development of students' English-language acquisition in concert with college readiness mathematics courses.

## Conclusion

Improving mathematics achievement in urban schools will require advocacy for shifts in policy structures. Our commitment to equitable educational policies and practices informs our perspective as urban school researchers. We analyzed measures of students' mathematics achievement not to reproduce deficit discourses of disparities but rather to identify the institutional supports, resources and services necessary to improve the mathematics achievement of urban school students. Through our results, we show that all urban high school students benefit from participating in higher level mathematics courses. Urban schools committed to fostering equitable policy structures and pedagogical practices require creative strategies for accelerating students' participation in college readiness curricula in general, and higher level mathematics in particular. Programming policies that actively

delay, or indifferently ignore, urban school students' participation in higher level mathematics must be challenged. In addition, educators responsible for designing, implementing, and assessing teaching and learning in higher level mathematics courses must be committed to providing appropriate language and literacy support for all students, and for LMs in particular, to maintain students' interest and safeguard course completion. Specifically, LMs learn mathematics and English simultaneously and benefit from integrated and designated language acquisition strategies embedded in college readiness coursework.

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[i]  $g_1$  is a parameter vector describing the impact of the individual-level controls  $Z_{ij}$

[ii]  $g_2$  is a parameter vector describing the impact of the school-level controls  $Z_j$

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