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Why are the Early Elementary Race/Ethnicity Test Score Gaps in Science Larger than Those in Reading or Mathematics? National Evidence on the Importance of Language and Immigration Context in Explaining the Gap-in-Gaps

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Abstract: Recent work examining science test performance in the earliest grades of school has demonstrated that science test score gaps by race/ethnicity are apparent as early as kindergarten and that, in a number of cases, the racial/ethnic test score gaps in science are significantly larger than the corresponding gaps in reading or mathematics. This study explores the factors that explain the differences in the magnitudes of racial/ethnic disparities in performance on science standardized tests as compared to those in reading/mathematics. Drawing on nationally representative data from over 10,000 kindergartners in the 2010-11 school year, this study employs regression models that examine the explanatory power of nine conceptual domains for explaining the “gap-in-gaps” or test score gap differences in science relative to mathematics or reading. Results indicate that the gap-in-gaps is relatively unchanged by the inclusion of many conceptual domains but that students’ language and immigration contexts do explain substantial portions of the gap-in-gaps for Hispanic and Asian students. Implications for policy and practice are discussed.

Keywords: Equity; achievement gaps; disparities; kindergarten; ECLS

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Introduction

Emerging evidence suggests that early elementary science test score gaps by race/ethnicity are larger than the corresponding gaps in reading and mathematics and may arise from distinctive factors (Curran & Kellogg, 2016). For example, using nationally representative data from the Early Childhood Longitudinal Study of 2010-11 (ECLS-K:2011), prior work showed that the kindergarten test score gap between Hispanic and White students is approximately twice as large in science than it is in reading or mathematics (Curran & Kellogg, 2016). Perhaps more surprisingly, Asian students were found to have standardized test scores about a half standard deviation below their White peers in kindergarten science despite scoring as well or better than White students in reading and mathematics (Curran & Kellogg, 2016).

In short, then, early elementary test score gaps in science do not merely mirror those in mathematics or reading, and, for a number of subgroups, can be substantially larger. In this paper, we refer to these differences in the size of racial/ethnic test score gaps in science and those in reading or mathematics as the “gap-in-gaps”, reflecting a gap in the size of the racial/ethnic test score gaps across subjects. For example, if the Hispanic-White test score gap in mathematics is -0.5 standard deviations (SD) and in science is -0.9 SD, we conceptualize the gap-in-gaps as the difference of -0.4 SD. In other words, the gap-in-gaps reflects the extent to which racial/ethnic disparities in early elementary science differ from those in the more commonly tested subjects of reading and mathematics.

Understanding the gap-in-gaps with regard to early elementary science is important for several reasons. First, it may point attention to subgroups of students who are differentially excelling or struggling in science as compared to other subjects. This could suggest opportunities to learn from their successes in science and leverage these successes to support test

performance in other subjects, or it could point to the need for specific science interventions for groups of students who may not need additional supports in other subjects. Second, a greater understanding of the gap-in-gaps could yield insights into differential contributors to disparities in test performance across subjects. While it is possible that some factors (such as a disproportionate exposure to poverty) may contribute to test score gaps in all subjects, it is possible that other factors (like differential access to zoos or museums) could contribute to disparities in science test performance while having less of an impact on test performance in reading or mathematics. Identifying specific predictors of average differences in test scores across subjects could therefore allow for more tailored solutions to enhancing equity in science.

Despite the potential importance, to date, little work has explored the factors that explain such gap-in-gaps, whereby “explain” we mean factors that, after accounted for, alter the magnitude of the gap-in-gaps. The purpose of this study is to explore the degree to which a number of student, family, and contextual factors explain the differences in racial/ethnic science test score gaps as compared to those in reading or mathematics. To that end, the following research questions are addressed:

- 1) What is the relationship between race/ethnicity and differences in relative performance on a kindergarten science assessment as compared to kindergarten reading and mathematics assessments?
- 2) To what extent do students’ individual, familial, and cultural contexts as well as their early science learning opportunities explain the relationship between race/ethnicity and differences in relative performance on a kindergarten science assessment as compared to kindergarten reading and mathematics assessments?

The answering of these questions has the potential to inform our understanding of the nature of early science test score gaps and the ways such gaps differ from those in other subjects. Doing so may inform educator practice and interventions designed to improve equity in early science test performance. In the following sections, we begin by reviewing prior literature and then outline conceptual domains of explanatory factors that might be expected to explain differences in relative science test performance as compared to other subjects. We then proceed to a description of our methodology and data followed by a discussion of results and implications.

Background

Differences in Test Score Disparities between Science and Reading/Mathematics

Disparities in standardized test performance in the earliest grades of schooling in reading and mathematics have been well documented in the literature (Vanneman, Hamilton, Anderson, & Rahman, 2009; Reardon, 2011; Vanneman et al., 2009; Fryer & Levitt, 2004; 2006; Quinn, 2015). The causes of these disparities, particularly in kindergarten, are largely contextual with much of the differences being explainable by differences in socio-economic status and home/neighborhood contexts (Fryer & Levitt, 2004; Quinn, 2015).

Given that the causes of test score gaps in reading and mathematics would be expected to impact student test performance across subjects, it is not unexpected that racial disparities in performance on standardized tests would also exist in early science. Interestingly, however, recent work with the ECLS-K:2011 examining the kindergarten year has demonstrated how such science gaps, while present, tend to be significantly larger than those in reading or mathematics and, for some subgroups, exist even when disparities in reading and mathematics do not. Curran and Kellogg (2016) found that the test score gap between White students and Black and Hispanic students is up to twice as large in science than in reading or mathematics. Perhaps of most

surprise, however, was that White students scored over half a standard deviation higher in science than their Asian peers in kindergarten, despite scoring slightly lower in reading and mathematics (Curran & Kellogg, 2016). In other words, a significant test score gap exists between Asian students and White students in science that is not present at all in reading or mathematics.

Such differences in the science test score gap between White and Asian students has been documented in other work as well. Using the original ECLS-K (begun in 1998), Morgan and colleagues found that White students performed higher than Black, Hispanic, and Asian students on standardized tests of science at third grade (2016). Similarly, Quinn and Cooc documented higher scores in science among White students as compared to Asian students in third grade though the gap actually favored Asian students in reading and mathematics (Quinn & Cooc, 2015; Quinn, 2015). While evidence from the ECLS-K showed that the gap between White and Asian students in science tended to disappear by the end of elementary and middle school grades (Morgan et al., 2016; Quinn & Cooc, 2015), understanding why such a gap exists in science between these groups when not existing in reading or mathematics is of importance. To date, little empirical research has explored this issue.

Potential Explanations for Differences in Test Score Gaps across Subject Areas

In an attempt to explore these differential test score gaps across subjects, we drew on the theoretical framework of ecological systems theory (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 1998). Ecological systems theory emphasizes the way in which the educational development of young learners is situated in a number of conceptual systems. These systems, which include both characteristics of the individual as well as environmental contexts, potentially contribute to the development of students' academic ability (Bronfenbrenner, 1979;

Bronfenbrenner & Morris, 1998). Important to the ecological systems framework is the role of an individual's cultural context and the ways in which such a context interacts through politics, media, industry, and societal interactions to shape the development of the individual (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 1998). Researchers have used ecological systems theory to help understand the role of various science education interventions, such as high school STEM programs and informal science programs tailored to African American children (Bottia, Sterns, Mickelson & Moller, 2018; Simpson & Parsons, 2009). Furthermore, Morton and Parsons (2018) used this framework to highlight the role of intersectional race and gender identity for Black women in STEM. Central to this paper's exploration of the gap-in-gaps is a proper understanding of students' situational contexts.

Recent discourse on equity in science has highlighted how engagement with scientific learning is shaped by the historical and ongoing political and societal contexts with regard to race/ethnicity (Philip & Azevedo, 2017). In particular, science fields have a long history of under-representing racial minorities, privileging discourse and inquiry that is culturally aligned with the dominant culture, and leveraging the often well-paying and prestigious scientific jobs as means of reproducing privilege among the dominant racial group (Philip & Azevedo, 2017). To the extent that these systems may vary systematically across students of different race/ethnicity and academic subjects, they serve as potential explanatory factors in systematic differences in test scores by race/ethnicity across subjects.

As posited by ecological systems theory, students' standardized test performance is potentially influenced by factors in a range of conceptual domains: individual, familial, contextual, and structural components of their environment. Individual characteristics such as a child's inquisitiveness or approach to inquiry may be uniquely important to scientific test

performance as compared to test performance in other subjects (Wright & Neuman, 2009; French, 2004; Bennet, Spicola, & Vogelsang, 1970; Lehr, 2005). Likewise, familial contexts, such as variation in the scientific dialogue and vocabulary use that children experience with adults can both influence scientific knowledge and vary by parental education or socio-economic background (Callanan, 2006; Harris & Koenig, 2006; Hart & Risley, 2003; Mercer, Dawes, Wegerif, & Sams, 2004; Wright & Neuman, 2009). Such variation could be particularly pronounced for students whose home language is not English and therefore experience such dialogue and scientific vocabulary in a mix of languages and cultural contexts and with a more limited vocabulary in any given language (Fer, 2016; Sonnenschein, Galindo, Simons, Metzger, Thompson, & Chung, 2016). While this could affect the scores of English language learners across subjects, it could also contribute to the gap-in-gaps if standardized tests in science require more specialized language than assessments in reading or mathematics. Additionally, home contexts could lead to differential exposure to both informal learning as well as formal early childhood education contexts outside of the home. For instance, exposure to home learning activities has been shown to vary by race/ethnicity as has access to preschool (Curran, 2017; Sonnenschein & Sun, 2016). In short, then, there are a variety of individual, familial, and cultural contextual factors as well as differences in informal and formal science learning opportunities that may explain differences in early test score gaps in science relative to other subjects.

Summary

Given the multitude of potential contributors to test performance in the early years of formal schooling, our analyses empirically explored a number of conceptual domains as explanatory factors in differences in test score gaps across subjects in the first year of formal

schooling. In doing so, we provide some of the first empirical evidence from nationally representative data on the factors that explain differences in test score gaps between science and reading/mathematics in kindergarten. While our study cannot identify causal effects of individual factors, the results may nevertheless inform policies and practices that can help improve equity in early science test performance.

We note also that our work contributes to a discourse in which the value and appropriate way of discussing disparities in student performance are debated. Critical scholars point to the potentially problematic consequences of an overemphasis on disparities in test score performance or what is often termed the “achievement gap” (Ladson-Billings, 2006; 2007; Gutiérrez, 2008; Milner, 2012). In this study, we have purposefully used the term “test score gap” rather than “achievement gap” to avoid narrowly defining achievement within science as performance on a standardized test. Other scholars have preferred to focus attention on “opportunity gaps” or “the education debt” as ways of describing the historical inequities and continuing structural disadvantages faced by certain minority groups (Ladson-Billings, 2007; Milner, 2012). It is important then to explicitly note that, while this study attends to differences in test scores across groups, these differences reflect a long and ongoing history of discrimination rather than shortcomings of particular groups themselves. These facts notwithstanding, we nevertheless argue that there is value in nationally representative estimates using standardized measures given both the need for generalizable and broad understandings of the issue and the role of such measures in education policy debates. Consequently, we turn next to an overview of the data and analytic approach that allows us to explore the gap-in-gaps between racial/ethnic science test score gaps and those in reading/mathematics.

Data

We used data from the ECLS-K:2011. The ECLS-K:2011 is a nationally-representative data set of children in both public and private schools that attended either part-day or full-day kindergarten in the 2010-2011 school year. A wide range of questions were asked of the students as well as of their families, teachers, schools, and before/after-care providers, allowing researchers to explore relationships between students' lives in their schools, homes, and communities. For this study, we focused on a weighted sample of 10,565 kindergarten students who had data on science, mathematics, and reading assessments in the spring of the kindergarten year as well as indicators of race/ethnicity. Observations missing data on other covariates were retained through the use of multiple imputation.

We were specifically interested in student performance on the standardized science, reading, and mathematics assessments administered during the spring of students' kindergarten year. For each of these assessments, the assessors presented images (pictures, letters, numbers, short sentences, etc.) to the children on an easel and asked them questions related to those images. The students were not required to write anything and so could point to their answer (or otherwise verbalize it). Prior to the assessments, students were screened for English language proficiency, and students were not given the science assessment if they did not meet a certain threshold. Very few students, less than two percent of the overall sample, did not participate in the science assessment due to this screening. That said, our analysis only includes students that demonstrated at least a minimal level of English language proficiency.

The science assessment covered topics on the physical, life, and environmental sciences as well as on scientific inquiry. It was designed based on commonalities in the 2009 science state standards from six states (Arizona, California, Florida, New Mexico, Texas, and Virginia) as well as through feedback from educators and subject area curriculum specialists. As a result,

the assessment had strong validity, reflecting both expert input and state standards. The science assessment was field tested prior to finalization and administration and had a reliability of 0.75 (Tourangeau, Nord, Sorongon, Hagedorn, Daly, & Najarian, 2015). Unfortunately, the test questions are proprietary and not made available to researchers; consequently, further details on the exact questions asked are limited.

The reading and math assessments were developed in a similar fashion. The reading assessment covered topics such as print familiarity, letter recognition, rhyming, vocabulary, and reading comprehension. The reading assessment items were developed based in part on the 2009 National Assessment of Education Progress (NAEP) Reading Framework and state standards from the previously mentioned six states. In addition, subject matter experts and educators screened items and provided input. The math assessment measured the students' skills in conceptual and procedural knowledge as well as in problem solving. It was developed from the 1996 NAEP framework and the 2009 state standards of the six beforementioned states. Like the reading and science assessment, it was subjected to input from an expert panel of educators. Both reading and mathematics assessments were field tested prior to use. The reliabilities of the reading and mathematics assessments were 0.95 and 0.94 respectively. A more complete description of the assessments can be found in the ECLS-K:2011 User's Manual (Tourangeau et al., 2015).

Dependent Variables

Our dependent variables of interest were the difference in a student's standardized performance on the science assessment and the student's standardized performance on the reading/mathematics assessment. In other words, we were interested in the difference between where a student's science test score fell in the distribution of all students' science test scores as

compared to where that student's reading/mathematics test score fell in the distribution of all students in those subjects. Data on student performance on the assessments came from theta scores derived from item response theory (IRT) measures.

To create our dependent variables, we first standardized the science, reading, and mathematics scores within subject so that each student's score was recorded in standard deviation units from the mean score (mean of zero and standard deviation of one). We then created our dependent variable by taking the difference of each student's standardized science score and their standardized reading or mathematics score. This created two key dependent variables of interest, one representing the difference in a student's relative test performance in science compared to his or her relative position in reading and a second variable representing the difference in a student's relative test performance in science compared to his or her relative position in mathematics. These variables can be understood as the extent to which a student's position in the science test score distribution differs from her/his position in the reading or mathematics test score distribution. Systematic differences in these variables by race/ethnicity indicate a gap-in-gaps, which is to say systematic differences in the size of the race/ethnicity test score gap in science as compared to the race/ethnicity gap in reading or mathematics. We note that our approach of taking a difference in test scores across subjects yielded the same results as estimating separate regressions by subject area and then calculating the difference in corresponding coefficients and their statistical significance across each model using the seemingly unrelated estimation technique for multiply imputed data described by Cañette and Marchenko (n.d.). We prefer the differenced dependent variable for parsimony in presentation of the findings.

Independent Variables

Key to exploring the research questions at hand was understanding how the gap-in-gaps varied by race and ethnicity. Consequently, our key independent variables were binary indicators of race/ethnicity. We included mutually exclusive indicators for White, Black, Hispanic, Asian, and other. The “other” category included students who were identified as Native Hawaiian, Pacific Islander, American Indian, Alaskan Native, or two or more races each of which were relatively low frequency categories. These indicators of race/ethnicity came from student and parent reports to survey questions in the ECLS-K:2011. While admittedly masking much nuance in the racial/ethnic identification of many students, particularly in the “other” category, these categories were useful for examining relationships at a national scale and were consistent with the operationalization of race/ethnicity in prior studies using the ECLS-K:2011 data.

Explanatory Variables

Given the nature of our research questions, we were interested in the extent to which a number of conceptual domains explained differences in the magnitude of science test score gaps and reading/mathematics gaps. Consistent with prior literature, we use the term “explain” in a non-causal sense to reflect the degree to which the inclusion of a covariate changes the size of the estimated gap-in-gaps rather than the extent to which the given covariate causes the gap-in-gaps (Fryer & Levitt, 2004; Quinn & Cooc, 2015). To this end, we identified relevant covariates that fell under nine conceptual domains. Guided by the conceptual framing of the ecological systems framework, we examined conceptual domains that were specific to the individual student (inquisitiveness), specific to the family context (dialogue with adults; socio-economic status; reading activities; activities in the home), specific to the cultural context (language and immigration), specific to informal learning opportunities outside of the home (exposure to nature and the outdoors; activities out of the home), and specific to formal early learning opportunities

(type of pre-kindergarten childcare).

Each of the nine conceptual domains included a vector of relevant variables. For instance, inquisitiveness included measures of a child's eagerness to learn and interest in a variety of topics. Dialogue with adults included measures of discussing family traditions or heritage, frequency of eating meals together, and time spent with adults in the household among others. Measures of socio-economic status included parental education, family income, and parental occupation types. Measures of citizenship, second language use in the house, and parental birthplace were among those included in the language and immigration domain. Reading activities included measures of books in the home, time spent reading, and visits to libraries and bookstores among others. Activities in the home included computer usage, art activities, and playing games among others. Playing outside, visiting aquariums or zoos, and talking about nature among were among the measures included in the exposure to nature, outdoors, and science activities category. Activities out of the home included, among others, going to a play, participating in group sports, and partaking in academic activities. Finally, type of pre-kindergarten childcare included binary indicators of preschool care type such as Head Start or center-based care. Each of the covariates came from parental/guardian survey responses. The full list of covariates included in each conceptual domain are included in Appendix A.

Methods

To examine the extent to which these various conceptual domains explained the relative differences in racial/ethnic test score gaps across subjects we used ordinary least squares regression to estimate equation 1 in which all of the variables in each conceptual domain are represented by a topical vector name (i.e. each of the race variables are included in the vector "Race"). Specifically, we estimated the following equation:

$$(1) \quad \text{ScienceScore-OtherSubjectScore}_i = \beta_0 + \beta_1 \text{Race}_i + \beta_2 \text{Inquisitive}_i + \\ \beta_3 \text{Dialogue}_i + \beta_4 \text{SES}_i + \beta_5 \text{Lang\&Immig}_i + \beta_6 \text{Reading}_i + \beta_7 \text{HomeAct}_i + \\ \beta_8 \text{Nature}_i + \beta_9 \text{OtherAct}_i + \beta_{10} \text{Childcare}_i + \varepsilon_i$$

where *ScienceScore-OtherSubjectScore* is the difference between individual *i*'s standardized science score and their standardized reading or mathematics score (depending on the model); *Race* represents a series of binary race/ethnicity indicators; *Inquisitive* represents a series of proxy measures for each individual's level of inquisitiveness; *Dialogue* represents measures of how much time each individual dialogues with adults; *SES* represents indicators of parental education, income, and occupation; *Lang&Immig* represents a series of variables related to each individual's language usage and their family's immigration history; *Reading* represents a set of measures of each individual's level of reading activities at home; *HomeAct* is a set of variables that measure each individual's level of engagement in certain activities in the home; *Nature* represents measures of each individual's exposure to the outdoors or specific science-related activities; *OtherAct* is a series of variables that measure each individual's level of engagement in certain activities outside of the home; and *Childcare* is a set of binary indicators that represent the kind of pre-kindergarten childcare that each individual received.

We first estimated a specification of this model in which we only included *Race*. In this specification, the coefficients on each of the race/ethnicity indicators represented the extent in standard deviation units to which the science test score gap between that race/ethnicity category and White students differs from the corresponding test score gap in reading or mathematics. For instance, in models predicting the difference between a student's standardized science test score

and reading test score, a coefficient of -0.4 on the indicator for being Black would indicate that, on average, the test score gap between Black students and White students in science is four tenths of a standard deviation larger than that between Black students and White students in reading. In other words, the coefficients on the race/ethnicity indicators pick up the gap-in-gaps between science test scores and that of reading/mathematics.

In addition to the base model, we also estimated separate specifications in which we controlled for each of the nine conceptual domains hypothesized to potentially explain differences in science test score gaps compared to test score gaps in other subjects. For example, in our second specification, we included the race indicators as well as a vector of student measures of inquisitiveness. The change in the value of the coefficients on the race/ethnicity indicators from the first to the second specification allowed us to estimate the amount of the gap-in-gaps that is accounted for by the “inquisitiveness” conceptual domain. Similarly, we estimated models in which we controlled for each of the other conceptual domains in order to explore the extent to which each of those domains explained differences in test score gaps across subjects. Finally, we estimated a specification that included all nine conceptual domains.

We reiterate here that our analytic approach was descriptive in nature. The purpose of our research questions was to explore the extent to which a variety of conceptually relevant domains may mitigate differences in test score gaps between science and other subjects. Given this, our methodological approach did not allow for the isolation of causal effects of any given covariate or set of covariates on test performance or gaps in test performance. Consequently, we generally focus on the explanatory power of broader conceptual domains rather than that of individual covariates within these domains. In doing so, our work has the potential to point to areas (be they differences in home context, community activities, formal school environments,

etc.) that may benefit from further research to understand the dynamics of science test score gaps and the interventions that might reduce them.

Results

The findings of our analysis suggest that the relative differences in the size of the racial/ethnic science test score gap and the corresponding gaps in reading and mathematics are generally robust to the inclusion of a number of explanatory factors. That said, we did find that one of our conceptual domains, language and immigration, explained away some of the differences in magnitude of racial/ethnic test score gaps across subject areas. In this section, we present the results of our empirical models that support these findings.

Descriptive Statistics

Table 1 provides descriptive statistics on our key independent and dependent variables of interest for both the full sample and for racial/ethnic subgroups. With regard to race/ethnicity, our full sample was approximately 57% White, 12% Black, 22% Hispanic, 4% Asian, and about 5% other race – rates that generally reflect the national racial/ethnic composition of kindergarten students in the 2010 school year.

[Insert Table 1 about here]

In the top three rows of Table 1, we report means and standard errors on the standardized science, reading, and mathematics tests. While the measures are standardized (mean of zero, standard deviation of one), the means for the full sample are slightly higher than zero given restrictions to the analytic sample. As shown, test performance in science, reading, and mathematics varied across race/ethnicity. On average, White students tended to score higher than their Black and Hispanic peers across all subjects. Consistent with prior work, we found

that Asian students scored higher than White students in reading and mathematics but performed lower than White students in science.

Our key dependent variables – the measures of the difference in standardized science test performance and reading test performance or the difference in standardized science test performance and mathematics test performance – are shown beneath the assessment score measures. Given that test scores in each subject were standardized, the means of these measures are near zero in the full sample. While there were some outliers, almost all of the observations had values between -2.2 and 2.2 standard deviations for each of the dependent variables (not reported in the table). Across columns 2-6, we show these measures for each of the race/ethnicity groups. As shown, on average, White students' relative position in the distribution of science test scores tended to be higher than their relative position in the distribution of reading or mathematics test scores. The opposite is true for Black, Hispanic, and Asian students. The ranges of the dependent variables were also generally similar across racial/ethnic groups, with the exception of Asian students for whom the range of values tended to be distributed somewhat more in the negative direction than other groups. We turn next to results of regression models that formally estimated the relationship between these indicators of race/ethnicity and these dependent variables of interest.

Gap-in-Gaps between Science and Reading Test Performance

In Table 2, we report results of regressions predicting the difference in students' standardized science test scores and their standardized reading test scores in the spring of kindergarten. Column 1 shows coefficients and standard errors from the base model, that containing just the indicators of race/ethnicity. As shown, Black, Hispanic, and Asian students tended to, on average, have a larger and more negative gap in test scores between science and

reading than their White peers. For example, we found that, on average, the test score gap between Black students and White students in science was four tenths of a standard deviation larger (in the negative direction) than that between Black students and White students in reading. Consistent with the descriptive findings in Table 1, we found that the largest difference in test score gaps across subjects existed for Asian students. While Asian students outperformed their White peers in reading, they underperformed their White peers in science. Notably, however, Asian students performed better, on average, in reading than their Black or Hispanic peers despite having a larger gap-in-gaps (see Figure 1).

[Insert Table 2 about here]

In columns 2-11 of Table 2, we explored the extent to which each of the nine conceptual domains explained the gap-in-gaps. If, for example, controlling for the type of pre-kindergarten childcare explained the difference in the size of the science test score gap as compared to the reading test score gap, we would expect the coefficients on each of the race/ethnicity variables in these models to move towards zero. This would mean that, once accounting for this conceptual domain, the size of the racial/ethnic test score gap in science was comparable to that in reading.

We found, however, that the size of the gap-in-gaps was robust across almost all of the conceptual domains. This was evidenced by the largely unchanging coefficient estimates on each of the race/ethnicity indicators across models adding controls for each of the conceptual domains. That said, one conceptual domain did show meaningful changes in the size of the gap-in-gaps. In particular, controlling for indicators of language and immigration contexts reduced the gap-in-gaps for Hispanic and Asian students by around 50%.

Gap-in-Gaps between Science and Mathematics Test Performance

Turning to results comparing gaps in science test scores to those in mathematics, Table 3 presents estimates from models predicting the difference in a student's standardized science test score and standardized mathematics test score. As before, column 1 shows coefficients and standard errors from the base model, that containing just the indicators of race/ethnicity. Like with reading, Black, Hispanic, and Asian students tended to, on average, have a larger and more negative gap in test scores between science and mathematics than their White peers though the magnitude of the difference tended to be a bit smaller with mathematics than with reading. As with reading, we found that the largest difference in test score gaps across subjects existed for Asian students. Notably, however, as with reading, Asian students performed better, on average, in mathematics than their Black or Hispanic peers despite having a larger gap-in-gaps (see Figure 1).

[Insert Table 3 about here]

As in Table 2, columns 2-11 of Table 3 added vectors of controls for each of the nine conceptual domains. Like with comparisons to reading, we found that the size of the gap-in-gaps was generally consistent across almost all of the conceptual domains. As before, we found that controls for the language and immigration domain greatly reduced the gap-in-gaps for Hispanic and Asian students. In particular, when controlling for language and immigration indicators, the difference in the test score gap in science and mathematics for Hispanic students was reduced by about 75% while that for Asian students was reduced by almost 50%.

The Role of Language and Immigration Contexts in Explaining the Gap-in-Gaps

Given the importance of the language and immigration conceptual domain for explaining differences in science test score gaps and those in reading/mathematics for both Hispanic and Asian students, we further probed this relationship by examining the racial/ethnic test score gaps

in each subject with and without controls for language and immigration contexts. While it is possible that the reduction of the gap-in-gaps could be driven by changes in the size of the science test score gap when controlling for these indicators, it is also possible that the size of the reading or mathematics gaps could have increased after controlling for language and immigration contexts. In Figure 1, we show point estimates from regression models predicting test scores from race/ethnicity indicators for science, reading, and mathematics both without (left panel) and with controls for language and immigration (right panel). As shown, the addition of controls for language/immigration tended to reduce the size of the science test score gap for Hispanic and Asian students rather than substantively change the size of the test score gap for these groups in reading or mathematics.

[Insert Figure 1 about here]

To further unpack the role of language and immigration contexts in explaining differential racial/ethnic test score gaps in science as compared to reading or mathematics, we present results of regression models in which covariates from the language and immigration conceptual domain were progressively added to the set of covariates. We show results from models predicting the reading-science gap-in-gaps in Table 4 and those from models predicting the mathematics-science gap-in-gaps in Table 5. As shown, in both tables, we began with the unadjusted model (column 1) and then added controls for foreign language spoken in the home (column 2), parental proficiency with English (column 3), parent-child interactions in a foreign language (column 4), and citizenship/parental birthplace (column 5). Finally, column 6 shows a model including all of our language and immigration covariates simultaneously.

[Insert Table 4 about here]

[Insert Table 5 about here]

It is important to note that the language and immigration context of students differed systematically across race ethnicity. For example, while less than 9% of Black and 5% of White students used a non-English language at home, 70% of Hispanic and 78% of Asian students did so. Similarly, while around 5% of White and 10% of Black students' parents were immigrants, over 50% of Hispanic students and 80% of Asian students' parents were born outside the United States. Examining the changes in the coefficients on the race/ethnicity indicators across each model revealed that the inclusion of any of the language/immigration context covariates tended to reduce the size of the gap-in-gaps between science and both reading and mathematics. In general, the reduction in the gap-in-gaps was about the same across each of columns 2-5, with the exception of a slightly larger decrease when controlling for citizenship/parental birthplace for Asian students. Such a similar reduction in the gap-in-gaps across different language/immigration indicators is not surprising given that each set of covariates would be expected to be correlated with other indicators of language and immigration context. Examining results from the fully specified model (column 6) provides a view of the extent to which the reductions were driven by specific covariates, after holding constant other indicators of language and immigration contexts. As shown, in the fully specified models, the primary parent's proficiency with English as well as indicators of whether the child's parents were born outside of the U.S. remained as significant and meaningful predictors of a difference in the science race/ethnicity test score gap and the gaps in reading and mathematics. For the science-mathematics gap-in-gaps, the frequency that a child read in a foreign language was also a strong predictor of the gap-in-gaps. These results then lend support to the idea that there are systematic differences in the language, culture, experiences, and/or assessment of students that are English

language learners or are from families that have recently immigrated that meaningfully explain differences in science test scores relative to test performance in reading or mathematics.

Discussion

Taken as a whole, our results confirm prior findings that there are systematic differences in the magnitude of racial/ethnic gaps in kindergarten science test performance as compared to the corresponding gaps in reading or mathematics (Curran & Kellogg, 2016). The results demonstrate that these gaps are largely unchanged by the inclusion of a number of observable covariates. That said, the findings suggest that characteristics of a student's language and immigration background may be particularly important for Hispanic and Asian students in explaining differences in their relative performance between science and other subjects. Our results suggest that about half to three quarters of the gap-in-gaps for these groups is attributable to differences related to the students' language and immigration context.

It is important to recognize that the norms of both these groups are oppressively related to those of the dominant society. This being the case, contextualizing our results is a necessary part of a responsible approach to science education research (Parsons, 2008). We focus on the familial and school context, both a part of what ecological systems theory labels the microsystem, and how those interact with each other, which occurs in the mesosystem. Furthermore, conflicts between the context of the dominant society and the student at the level of the macrosystem, which looks at the cultural attitudes and ideologies, could result in systemic racism that manifests itself in how schools test for knowledge in science education or how formal and informal science learning environments engage with students. While our study was not designed to identify causal effects of individual characteristics of students, as part of our efforts to contextualize the results we consider here several possible reasons why language and

immigration indicators appear to explain such a significant portion of the gap-in-gaps for these groups.

Role of Language

First, for those students that are learning English as a second language, it is possible that the process of second language acquisition places constraints on the scientific vocabulary developed by students or the accurate assessment of such vocabulary by standardized tests. Prior work has shown that bilingual students tend to have lower receptive vocabularies within a given language than their monolingual peers (Bialystok, Luk, Peets, & Yang, 2010). Research on early language acquisition has documented “bilingual profile effects” in which bilingual students are found to perform differentially on different assessments of early language and literacy (Cobo-Lewis et al., 2002; Oller, Pearson, Cobo-Lewis, 2007). In particular, there is some evidence that gaps in performance between bilingual and monolingual children are larger in examinations that emphasize vocabulary as opposed to other aspects of early literacy, like phonics (Cobo-Lewis et al., 2002; Oller et al., 2007). In other words, while monolingual children are found to perform similarly across literacy assessments, bilingual students demonstrate more sensitivity to the nature of the particular assessment. Oller and colleagues (2007) attribute these differences, in part, to young learners distributing their vocabulary knowledge across languages, such that some terms are known in one language and not the other. To the extent that science test performance depends on knowledge and use of vocabulary specific to science (Kearsey & Turner, 1999), such bilingual profile effects may manifest themselves as lower science test scores among bilingual or English language learner students. This could be because science assessments, like more vocabulary heavy reading assessments, pick up knowledge of specific vocabulary. If bilingual students distribute part of their scientific vocabulary within their non-English language, then that

scientific knowledge, while existing, may not be demonstrated on a standardized assessment of science.

Indeed, prior work examining science assessments in elementary school aged children demonstrates the way in which language barriers can influence the communication of scientific knowledge. Examining responses to a science assessment by a large sample of third and fourth grade students, Luykx and colleagues documented how students commonly misconstrued science terms with everyday uses of words (2007). For instance, “gas” being equated to “gasoline” or “recording information” referring to audio recording (Luykx et al., 2007). They documented how such confusions were particularly salient for English language learners who might interpret scientific vocabulary in the context of vocabulary in their second language – such as a Spanish speaker linking “gaseosa” with liquid soft drinks (Luykx et al., 2007)

In a similar vein, work examining testing of English language learner students in the upper grades found that students often perform better when tested in the language they learned the subject matter in (Abedi, Lord, & Hofstetter, 1998; Abedi, Hofstetter, & Lord, 2004). While in the upper grades students have had a greater amount of science instruction in English and may be studying more advanced content that is not encountered outside of school, students in kindergarten may be more heavily influenced by the informal science learning that occurs in their native tongue in their out-of-school environments. As a result, while testing in a non-English language could negatively impact student performance in the upper grades, testing in English in the early grades might result in a greater test score disparity than would occur if tested in their native language.

While the data and analytic approach used in this study cannot explicitly test whether this mechanism or others cause the larger gap-in-gaps for Asian and Hispanic students, the

descriptive results do provide some suggestive support for a linguistic explanation. In particular, our findings show that how well the primary parent speaks English as well as how often the parent reads to the child in a foreign language are significant predictors of differences in the science and reading/mathematics gaps. To the extent that parents' language ability and engagement with the child in a language other than English results in a child having a more limited or distributed scientific vocabulary, these findings are consistent with the role of language being an important contributor to the gap-in-gaps. Unfortunately, the specific ECLS-K science assessment questions are not made available to the public, preventing any analysis of the level or type of vocabulary contained on the assessment. We note then the importance of future research further exploring the mechanisms and causal relationships by which language differences may influence the gap-in-gaps as well as work that examines the magnitude of the gap-in-gaps when different science assessments are used.

Racism arising from Cultural Discontinuities within Science Learning Environments

Next, prior research suggests that students who are English language learners or are from immigrant families may face discontinuities between the cultural context of their home environment and the dominant culture of science learning environments (Tyler et al., 2008). In addition to creating learning environments that are not attuned to the cultural context of students, such discontinuities may result in explicit or implicit bias on the part of the learning environment, such that these students experience systematic disadvantage in virtue of their background. Indeed, prior work demonstrates the tendency of educators to adopt deficit outlooks in which cultural discontinuities become interpreted as cultural deficiencies of the students (Ford, Harris, Tyson, & Trotman, 2001; Ford, Grantham, & Whiting, 2008; Garcia & Guerra, 2004). The result is a form of what has been termed "cultural racism" (Tyler et al., 2008).

It is possible that such racism arising from discontinuities between the cultural background of immigrant students and those of the dominant culture of science learning environments may also account for the explanatory power of student immigration context. In our models, we control for informal and formal science learning opportunities like going to the museum or zoo, engaging in extracurricular enrichment activities, and preschool attendance. That controlling for these kinds of activities and learning opportunities does not reduce the gap-in-gaps for these groups, suggests that the gap-in-gaps may not be driven by differences in access to such early science learning opportunities but perhaps differences in the ways in which these venues engage with early learners from different linguistic or cultural backgrounds. For example, while disparities in access to science museums have been documented (Dawson, 2014a; 2017; Feinstein, 2017), prior work has drawn attention to the fact that even when access to such resources is available, cultural discontinuities as well as explicit and implicit bias and racism may impact the degree to which students benefit from such access (Dawson, 2014a; 2014b; Feinstein, 2017). Feinstein notes, “neither museum science nor school science is equally welcoming to everyone. Typical science learning experiences, in school and out, are culturally specific: they are based on the experiences and norms of particular groups of people...” (2017, p. 535). Dawson conceptualizes these culturally influenced differences in the impact of informal science learning opportunities as being on a spectrum from “weak inclusion” to “strong inclusion” (2017). Our finding that controlling for informal and formal science learning opportunities does not reduce the gap-in-gaps but that accounting for proxies for cultural discontinuity (such as parental immigration) does fits with a conception of weak inclusion on the part of these early learning experiences and a cultural explanation for the gap-in-gaps. Consequently, Janzen recommends that “teachers must not only be familiar with science content

and how that content is constructed linguistically but also familiar with the cultural practices and ways of knowing espoused by different groups” (Janzen, 2008, p. 1029).

Our findings point to the potential role of cultural discontinuities in explaining the gap-in-gaps insofar as indicators of parental birthplace were significant predictors of larger racial/ethnic test score gaps in science than in reading or mathematics. Hispanic and Asian students with parents who were born outside of the U.S. may be more likely to face cultural discontinuities than those who come from families that have been in the U.S. for longer periods. To be clear, this does not imply that the cultural backgrounds of any subgroup of students are preferable to those of another but rather that different students with different backgrounds may find their background differentially represented in mainstream science experiences. As with our discussion of language, however, such an explanation related to cultural discontinuity of science learning environments and racism/bias arising from such discontinuities are hypothesized explanations that should be probed in future studies.

Biases of Science Assessments

In addition to differences in vocabulary and racism arising from cultural discontinuities, the nature of the science assessments themselves may contribute to the observed gap-in-gaps. First, scholars have argued that standardized tests suffer from various forms of bias that systematically impact minority students’ performance on the tests (Jencks & Phillips, 1998). Within the field of science, critics of standardized testing have pointed to a variety of ways in which the use of standardized assessments in science may be particularly biased relative to assessments in other domains (Penfield & Lee, 2010).

As previously alluded to, science assessments may be linguistically biased in ways that would systematically disadvantage students who are English language learners and in ways that

may be specific to the subject area of science, given its relatively unique vocabulary. Prior work notes how the relatively higher linguistic complexity of science assessments relative to other assessments may differentially impact non-native English speakers, introducing additional variance in their scores that is unrelated to the science content knowledge being assessed (Penfield & Lee, 2010). This concern is consistent with the previously discussed bilingual profile effects, in which language ability serves as a barrier to accurate assessment of science knowledge (Cobo-Lewis et al., 2002; Oller, Pearson, Cobo-Lewis, 2007).

In addition to such linguistic bias, science assessments may also be subject to what Solano-Flores and Nelson-Barber term “cultural validity” which captures the extent to which the assessment “addresses the sociocultural influences that shape student thinking and the ways in which students make sense of science items and respond to them” (2001). Indeed, as described by Penfield & Lee (2010), prior work has found that differences between students’ cultural backgrounds and the dominant cultural perspective of science assessments can impact their interpretation and responses to the assessment (Luykx et al., 2007; Noble et al., 2012). Such a discontinuity, if greater for science assessments than in other subjects, could explain part of the gap-in-gaps observed in this study.

Penfield and Lee also note the potential for measurement error in science assessments to differ across minority and majority groups, potentially as a function of the linguistic and cultural biases just discussed (2010). Such differential reliability could, in turn, attenuate the average performance of minority groups and exacerbate estimated achievement gaps (Penfield & Lee, 2010). Empirically, prior research has documented greater discrepancies in reliability of assessments between English language learner students and native English speakers in science than in other subjects, supporting the possibility that such measurement error may be larger in

science than in other subjects (Abedi, 2004). In the case of this study, this is a plausible explanation for part of the gap-in-gaps given that the ECLS-K science assessment had a considerably lower reliability than the corresponding reading and mathematics assessments, a product perhaps in part due to the relatively low number of assessment items (20) in the kindergarten year (Tourangeau et al., 2015).

Beyond Language, Racism from Cultural Discontinuities, and Testing Bias

While our exploratory analyses have uncovered the importance of language and immigration contexts as explanatory variables of the difference in size of racial/ethnic achievement gaps in science as compared to reading and mathematics, we note that these characteristics of students are not fully able to account for the gap-in-gaps. Even for Hispanic and Asian students, language and immigration covariates left somewhere between a quarter to half of the original gap-in-gaps unexplained. Furthermore, the explanations around language and culture offered in this discussion are speculative based on existing literature. While the design of this study is unable to definitively identify causes of the gap-in-gaps, the work suggests the ongoing importance of research and inquiry into other mechanisms that may influence differential performance on science assessments for racial/ethnic minority groups as compared to their relative performance in reading and mathematics.

Furthermore, we note that for Black students, the gap-in-gaps was not mitigated by any of the included covariates. While we can only hypothesize about the reasons for the remaining gap-in-gaps, there are several possibilities that further research might explore. First, there is a body of evidence around the impacts of stereotype threat on student testing. We are unaware of any work that tests differences in the magnitude of stereotype threat across subjects for early elementary students, but it is possible that such differences could exist. Another possibility is

that the remaining gap is in part a function of the specific assessments used in the ECLS-K. Future research might replicate this work with other assessments, particularly one with a more reliable science assessment.

Limitations

Like all research, this study has limitations. While the nationally representative nature of the dataset is an asset for drawing widely generalizable results, the nature of such wide-scale survey data is that many of the measures used in this study were broad indicators of children's experiences. That so many conceptual domains were unrelated to differences in test score gaps across subjects points to the nuanced nature of causes of disparities in science and other subjects. Future work that examines smaller samples in more detail, perhaps with qualitative components, holds great potential for furthering our understanding of the gap-in-gaps.

Secondly, we acknowledge that the study of test score gaps between broadly operationalized indicators of race/ethnicity is a limited view of equity in science. By default, it defines success relative to the dominant group of White students and measures performance through standardized assessments that are themselves likely to exhibit certain cultural biases. Prior work on equity in science has pointed to the many distinct subgroups contained under broad headings like "Asian" or "Hispanic", a nuance that our data does not let us explore (Lee, 1999). Scholars have pointed out these limitations in work on test score gaps, with calls for more developed views of equity (i.e. Philip & Azevedo, 2017). We therefore caution readers against the ecological fallacy of applying findings from broadly defined groups to individual students or subgroups within these broad categorizations.

Implications for Policy and Practice

Our findings have the potential to motivate a continued focus on achieving equity in science among various racial/ethnic groups. By identifying some explanatory factors of the gap-in-gaps, our work suggests the need for science instruction and interventions that better serve English language learners and students of different cultural backgrounds as well as assessments that reliably measure the scientific content knowledge of these groups. Prior work elsewhere has done a comprehensive job of synthesizing research around science instruction with English language learners and culturally diverse students (i.e. Lee, 2005; Lee & Buxton, 2010). More recent research has highlighted the potential for interventions and practices including teacher professional development (Adamson, Santau, & Lee, 2013; Diamond, Maerten-Rivera, Rohrer, & Lee, 2014; Llosa, Lee, & Jian, 2016) and integration of language development strategies or second languages into science instruction (Llosa, Van Booven, & Lee, 2015; Turkan, De Oliveria, Lee, & Phelps, 2014). Such practices and interventions, explicitly tailored to science, have the potential to reduce the gap-in-gaps and promote greater racial/ethnic equity in early science test performance. Finally, we note also that while the gap-in-gaps was largest for Asian students, their relative performance across all three subjects was, on average, higher than their Hispanic and Black peers. As a matter of policy and practice then, while the Asian gap-in-gaps is important to address, continued attention to disparities across all three subjects for Hispanic and Black students remains pressing.

Conclusion

Improving our country's capacity in the scientific disciplines remains a prominent policy goal; however, due to persistent disparities in science test performance, not one that all racial/ethnic groups are equally poised to participate in. Research has demonstrated the importance of early learning for setting the foundation of later performance in science and other

subjects (Claessens & Engel, 2013; Morgan et al., 2016). Recently, studies using nationally representative data have demonstrated the racial/ethnic gaps in science are larger than those in reading or mathematics in the earliest years of formal schooling, particularly for Asian and Hispanic students (i.e. Curran & Kellog, 2016). This study has used an exploratory approach to understanding such “gap-in-gaps”. We leveraged ecological systems theory to examine the extent to which a variety of conceptual domains, each representing different aspects of the students’ individual, familial, and cultural contexts, explained the difference in the size of the early science test score gap and those in reading and mathematics. The findings point to the important role of language and immigration contexts among Hispanic and Asian students in explaining these gap-in-gaps. In doing so, the findings point to the need for ongoing efforts in policy and practice to support the early learning opportunities of specific groups of students. Such efforts have the potential to reduce disparities and ensure that students of all racial/ethnic backgrounds are poised to contribute to future scientific endeavors.

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Table 1: Means and standard errors of achievement scores and differences in standardized scores across subjects by race/ethnicity

	Full Sample	White	Black	Hispanic	Asian	Other Race
Standardized science test scores	0.066 (0.032)	0.407 (0.023)	-0.424 (0.065)	-0.571 (0.045)	-0.109 (0.056)	0.229 (0.050)
Standardized reading test scores	0.048 (0.024)	0.200 (0.026)	-0.194 (0.055)	-0.295 (0.032)	0.482 (0.041)	0.076 (0.053)
Standardized math test scores	0.043 (0.030)	0.255 (0.035)	-0.394 (0.052)	-0.340 (0.039)	0.379 (0.041)	0.102 (0.048)
Difference in standardized science and reading test scores	0.018 (0.026)	0.207 (0.023)	-0.230 (0.051)	-0.276 (0.034)	-0.590 (0.054)	0.153 (0.073)
Difference in standardized science and mathematics test scores	0.023 (0.023)	0.152 (0.021)	-0.029 (0.042)	-0.231 (0.044)	-0.487 (0.054)	0.127 (0.051)
Student race is White	0.573 (0.020)	1.000 -	- -	- -	- -	- -
Student race is Black	0.122 (0.015)	- -	1.000 -	- -	- -	- -
Student race is Hispanic	0.216 (0.015)	- -	- -	1.000 -	- -	- -
Student race is Asian	0.036 (0.005)	- -	- -	- -	1.000 -	- -
Student race is other	0.053 (0.006)	- -	- -	- -	- -	1.000 -
Observations	10,565	5,796	1,209	2,199	705	656

Notes: Standard errors in parentheses. All estimates are weighted to account for the complex survey design of the ECLS-K.

Table 2: Coefficients and standard errors from regressions predicting standardized science-reading achievement gaps in spring of kindergarten from indicators of student race/ethnicity

	Thematic buckets controlled for in each specification										
	No Controls	Inquisitiveness	Dialogue with Adults	Socio-Economic Status	Language & Immigration	Exposure to Nature & the Outdoors	Reading Activities	Activities in the Home	Activities out of the Home	Type of Pre-Kindergarten Childcare	All Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Black	-0.437*** (0.0536)	-0.424*** (0.0528)	-0.479*** (0.0482)	-0.444*** (0.0486)	-0.414*** (0.0559)	-0.405*** (0.0509)	-0.382*** (0.0471)	-0.420*** (0.0516)	-0.427*** (0.0421)	-0.441*** (0.0525)	-0.391*** (0.0447)
Hispanic	-0.483*** (0.0356)	-0.467*** (0.0356)	-0.496*** (0.0367)	-0.405*** (0.0340)	-0.186*** (0.0318)	-0.434*** (0.0340)	-0.455*** (0.0351)	-0.480*** (0.0366)	-0.398*** (0.0467)	-0.483*** (0.0367)	-0.206*** (0.0342)
Asian	-0.798*** (0.0536)	-0.780*** (0.0542)	-0.792*** (0.0532)	-0.770*** (0.0544)	-0.467*** (0.0583)	-0.757*** (0.0522)	-0.761*** (0.0542)	-0.775*** (0.0545)	-0.656*** (0.0565)	-0.796*** (0.0537)	-0.420*** (0.0599)
Other Race	-0.0546 (0.0704)	-0.0529 (0.0701)	-0.0972 (0.0711)	-0.0607 (0.0619)	-0.0198 (0.0673)	-0.0460 (0.0694)	-0.0371 (0.0687)	-0.0540 (0.0678)	-0.0328 (0.0525)	-0.0553 (0.0704)	-0.0650 (0.0587)
Constant	0.207*** (0.0229)	-0.500 (0.2706)	0.0604 (0.1315)	-0.336*** (0.0903)	0.166 (0.0966)	-0.176* (0.0756)	0.0555 (0.1549)	-0.145 (0.1699)	0.216*** (0.0321)	0.175*** (0.0320)	-0.588 (0.3591)
Observations	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565

Notes: Standard errors in parentheses. All estimates weighted to account for the complex survey design of the ECLS-K. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

Coefficients on Hispanic and Asian indicators in column 5 and 11 are significantly ($p < 0.05$) different from that in column 1 on a Welch's t-test. All other coefficients are statistically indistinguishable from those in the uncontrolled model (column 1).

Table 3: Coefficients and standard errors from regressions predicting standardized science-math achievement gaps in spring of kindergarten from indicators of student race/ethnicity

	Thematic buckets controlled for in each specification										
	No Controls	Inquisitiveness	Dialogue with Adults	Socio-Economic Status	Language & Immigration	Exposure to Nature & the Outdoors	Reading Activities	Activities in the Home	Activities out of the Home	Type of Pre-Kindergarten Childcare	All Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Black	-0.182*** (0.0410)	-0.172*** (0.0398)	-0.240*** (0.0401)	-0.221*** (0.0379)	-0.163*** (0.0427)	-0.166*** (0.0404)	-0.157*** (0.0381)	-0.185*** (0.0413)	-0.191*** (0.0421)	-0.198*** (0.0403)	-0.212*** (0.0428)
Hispanic	-0.384*** (0.0471)	-0.369*** (0.0459)	-0.401*** (0.0481)	-0.331*** (0.0421)	-0.0945* (0.0380)	-0.353*** (0.0436)	-0.355*** (0.0442)	-0.385*** (0.0463)	-0.398*** (0.0467)	-0.396*** (0.0474)	-0.147*** (0.0420)
Asian	-0.640*** (0.0554)	-0.624*** (0.0556)	-0.635*** (0.0543)	-0.609*** (0.0546)	-0.358*** (0.0568)	-0.617*** (0.0541)	-0.614*** (0.0566)	-0.612*** (0.0558)	-0.656*** (0.0565)	-0.638*** (0.0548)	-0.334*** (0.0548)
Other Race	-0.0255 (0.0527)	-0.0244 (0.0525)	-0.0686 (0.0564)	-0.0493 (0.0479)	-0.000536 (0.0513)	-0.0200 (0.0526)	-0.0179 (0.0547)	-0.0283 (0.0509)	-0.0328 (0.0525)	-0.0320 (0.0521)	-0.0673 (0.0502)
Constant	0.152*** (0.0213)	-0.580* (0.2439)	0.162 (0.1160)	-0.331*** (0.0911)	0.0316 (0.0725)	-0.0975 (0.0802)	-0.0921 (0.1047)	-0.224 (0.1446)	0.216*** (0.0321)	0.129*** (0.0264)	-0.561 (0.3031)
Observations	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565

Notes: Standard errors in parentheses. All estimates weighted to account for the complex survey design of the ECLS-K. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

Coefficients on Hispanic and Asian indicators in column 5 and 11 are significantly ($p < 0.05$) different from that in column 1 on a Welch's t-test. All other coefficients are statistically indistinguishable from those in the uncontrolled model (column 1).

Table 4: Coefficients and standard errors from regressions predicting standardized science-reading achievement gaps in spring of kindergarten from indicators of student race/ethnicity: A closer look at language & immigration

	1	2	3	4	5	6
Black	-0.437*** (0.0536)	-0.423*** (0.0555)	-0.427*** (0.0541)	-0.430*** (0.0545)	-0.407*** (0.0568)	-0.414*** (0.0559)
Hispanic	-0.483*** (0.0356)	-0.260*** (0.0309)	-0.266*** (0.0335)	-0.243*** (0.0299)	-0.260*** (0.0385)	-0.186*** (0.0318)
Asian	-0.798*** (0.0536)	-0.549*** (0.0541)	-0.636*** (0.0572)	-0.575*** (0.0547)	-0.441*** (0.0556)	-0.467*** (0.0583)
Other Race	-0.0546 (0.0704)	-0.0235 (0.0666)	-0.0501 (0.0699)	-0.0346 (0.0680)	-0.00721 (0.0652)	-0.0198 (0.0673)
Controls for:						
A Foreign Language is Spoken in the Home		-0.340*** (0.0331)				-0.0459 (0.0711)
How well parent 1 speaks English (omitted group: very well)						
Pretty well			-0.229*** (0.0598)			-0.0664 (0.0607)
Not very well			-0.429*** (0.0557)			-0.218** (0.0650)
Not well at all			-0.426*** (0.0843)			-0.215* (0.0934)
How well parent 2 speaks English (omitted group: very well)						
Pretty well			-0.0866 (0.0626)			0.00489 (0.0644)
Not very well			-0.160* (0.0655)			-0.0628 (0.0675)
Not well at all			-0.186 (0.0984)			-0.103 (0.0988)
Conducts Activities in a Foreign Language (omitted group: always)						
Most of the time				0.109* (0.0474)		0.000342 (0.0494)
Sometimes				0.233*** (0.0526)		0.0282 (0.0539)
Never				0.426*** (0.0555)		0.0599 (0.0880)
Reads to the Student in a Foreign Language (omitted group: not at all)						
Once or twice a week				-0.0696 (0.0466)		-0.0367 (0.0466)
3-6 times a week				-0.203** (0.0635)		-0.131* (0.0630)
Everyday				-0.129 (0.0818)		-0.0524 (0.0835)
Student is a U.S. Citizen					-0.105 (0.0772)	-0.0596 (0.0789)
Parent 1 was Born Outside of the U.S.					-0.239*** (0.0355)	-0.112* (0.0463)
Parent 2 was Born Outside of the U.S.					-0.209*** (0.0380)	-0.123** (0.0421)
Constant	0.207*** (0.0229)	0.224*** (0.0235)	0.212*** (0.0231)	-0.206** (0.0629)	0.230*** (0.0235)	0.166 (0.0966)
Observations	10,565	10,565	10,565	10,565	10,565	10,565

Notes: Standard errors in parentheses. All estimates weighted to account for the complex survey design of the ECLS-K. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$; Coefficients on Hispanic and Asian indicators in columns 2-6 are significantly ($p < 0.05$) different from that in column 1 on a Welch's t-test. All other race/ethnicity coefficients are statistically indistinguishable from those in the uncontrolled model (column 1).

Table 5. Coefficients and standard errors from regressions predicting standardized science-math achievement gaps in spring of kindergarten from indicators of student race/ethnicity: A closer look at language & immigration

	1	2	3	4	5	6
Black	-0.182*** (0.0410)	-0.169*** (0.0422)	-0.172*** (0.0418)	-0.175*** (0.0419)	-0.153*** (0.0436)	-0.163*** (0.0427)
Hispanic	-0.384*** (0.0471)	-0.182*** (0.0412)	-0.150*** (0.0366)	-0.142*** (0.0361)	-0.169*** (0.0437)	-0.0945* (0.0380)
Asian	-0.640*** (0.0554)	-0.415*** (0.0548)	-0.473*** (0.0588)	-0.436*** (0.0546)	-0.296*** (0.0554)	-0.358*** (0.0568)
Other Race	-0.0255 (0.0527)	0.00256 (0.0506)	-0.0209 (0.0523)	-0.00895 (0.0515)	0.0199 (0.0488)	-0.000536 (0.0513)
A Foreign Language is Spoken in the Home		-0.307*** (0.0300)				0.0359 (0.0612)
How well parent 1 speaks English (omitted group: very well)			-0.206*** (0.0526)			-0.0774 (0.0595)
Pretty well			-0.470*** (0.0545)			-0.260*** (0.0649)
Not very well			-0.423*** (0.0783)			-0.193* (0.0835)
Not well at all						
How well parent 2 speaks English (omitted group: very well)						
Pretty well			-0.0916 (0.0567)			-0.0102 (0.0627)
Not very well			-0.198** (0.0617)			-0.104 (0.0648)
Not well at all			-0.259** (0.0903)			-0.171 (0.0932)
Conducts Activities in a Foreign Language (omitted group: always)						
Most of the time				0.198*** (0.0504)		0.0845 (0.0533)
Sometimes				0.312*** (0.0586)		0.0993 (0.0627)
Never				0.433*** (0.0572)		0.136 (0.0765)
Reads to the Student in a Foreign Language (omitted group: not at all)						
Once or twice a week				-0.127** (0.0385)		-0.0996* (0.0403)
3-6 times a week				-0.227*** (0.0659)		-0.158* (0.0698)
Everyday				-0.307** (0.0946)		-0.235* (0.0919)
Student is a U.S. Citizen					-0.118 (0.0678)	-0.0580 (0.0681)
Parent 1 was Born Outside of the U.S.					-0.226*** (0.0363)	-0.0814 (0.0479)
Parent 2 was Born Outside of the U.S.					-0.205*** (0.0406)	-0.108* (0.0444)
Constant	0.152*** (0.0213)	0.167*** (0.0209)	0.158*** (0.0213)	-0.269*** (0.0575)	0.174*** (0.0217)	0.0316 (0.0725)
Observations	10,565	10,565	10,565	10,565	10,565	10,565

Notes: Standard errors in parentheses. All estimates weighted to account for the complex survey design of the ECLS-K. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$; Coefficients on Hispanic and Asian indicators in columns 2-6 are significantly ($p < 0.05$) different from that in column 1 on a Welch's t-test. All other race/ethnicity coefficients are statistically indistinguishable from those in the uncontrolled model (column 1).

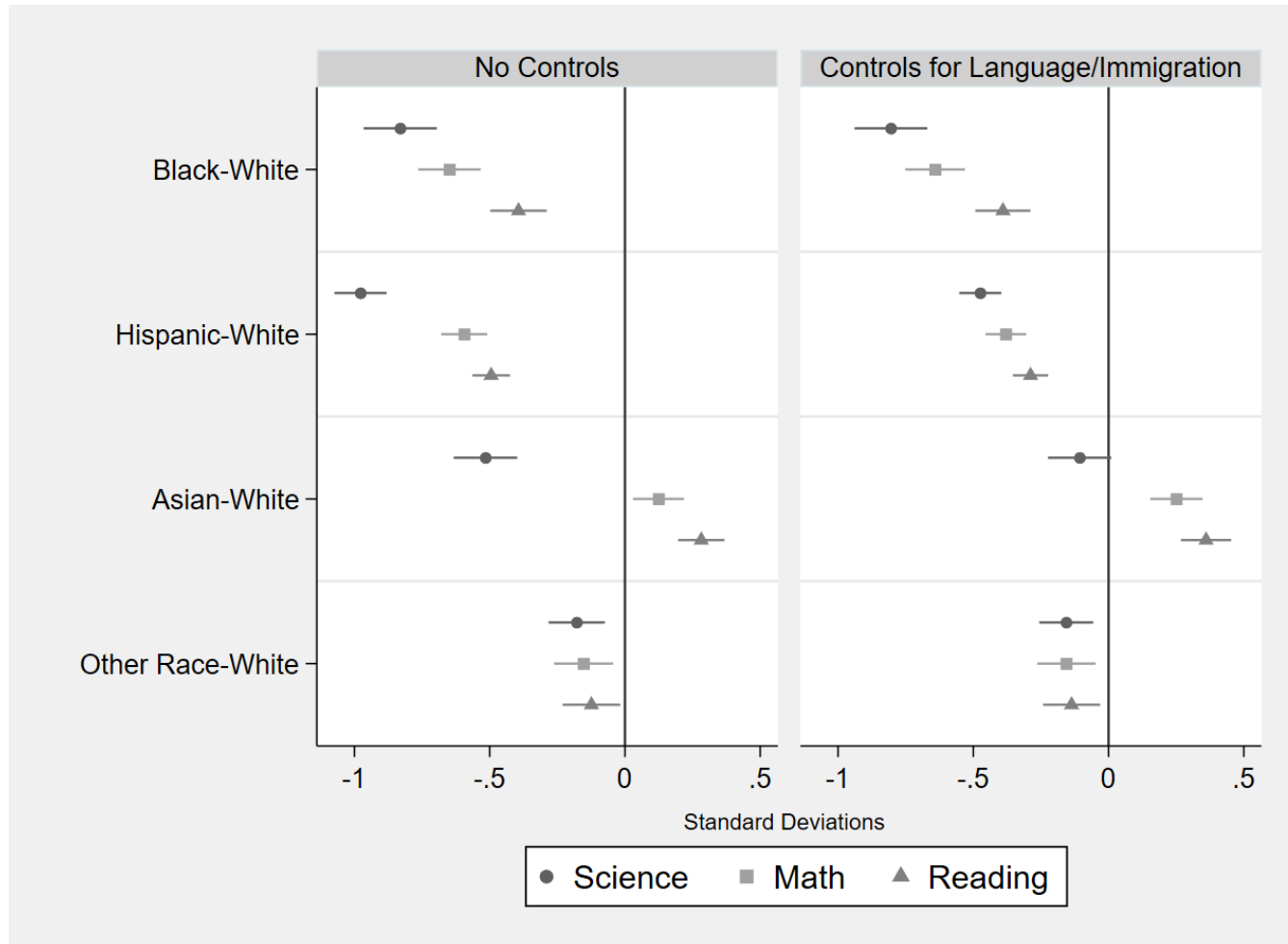


Figure 1: Point estimates and 95% confidence intervals for coefficients on race/ethnicity indicators from regressions predicting science achievement, mathematics achievement, and reading achievement both with out and with controls for language and immigration
 Note. Vertical red line represents no difference, on average, in achievement between White students and other subgroups. X-axis is in standard deviation units.

Appendix A: List of Variables within each Conceptual Domain

Inquisitiveness

Shows Interest in Variety

Is Eager to Learn

Is Creative in Work or Play

Dialogue with Adults

Frequency that the Parent Tells Stories to the Student

Number of Days in the Week Eat Dinner Together

Number of Days in the Week Eat Breakfast Together

Discusses the Family's Ethnic Heritage

Discusses Religious or Family Traditions

Time Spent with the Adult Male of the Household on Weekdays

Time Spent with the Adult Male of the Household on Weekends

Participates in Religious Activities

Socio-Economic Status

Person 1's Highest Level of Education

Person 2's Highest Level of Education

Family Income Level

Parent 1's Occupation

Parent 2's Occupation

Language and Immigration

A Foreign Language is Spoken in the Home

How Well Parent 1 Speaks English

How Well Parent 2 Speaks English

Conducts Activities in a Foreign Language

Reads to the Student in a Foreign Language

Student is a U.S. Citizen

Parent 1 was Born Outside of the U.S.

Parent 2 was Born Outside of the U.S.

Exposure to Nature, Outdoors, and Science Activities

Talks about Nature

Thinks it is Safe to Play Outside

Builds Stuff at Home

Participates in Playground Activities

Participates in Outdoor Recreational Sports

Has Visited an Aquarium or Zoo

Reading Activities

Reads Books to the Student

Amount of Time Spent Reading to Student
Number of Books the Student Has
How often the Student Reads Picture Books
Frequency that the Student Reads Outside of School
Has Visited the Library
Has Been to a Bookstore
Uses a Computer to Read Stories

Activities in the Home

Sings Songs in the Home
Does Art in the Home
Plays Games in the Home
Plays Sports at Home
Works with Numbers at Home
Has a Home Computer the Student Can Use
Frequency the Student Uses the Computer
Uses a Computer to Learn Skills
Uses a Computer to make Art
Uses a Computer to Access the Internet

Activities out of the Home

Has Gone to a Play, Concert, or Show
Has Visited an Art or History Museum or a Historical Site
Partakes in Academic Activities
Takes Dance Lessons
Participates in Organized Athletic Activities
Participates in Recreational Programs
Takes Music Lessons
Takes Drama Classes
Takes Art Classes or Lessons
Participates in Performing Arts Programs
Takes Craft Classes or Lessons
Participates in Group Sports
Participates in Individual Sports
Receives Exercise Through Dance
Takes Martial Arts Lessons

Type of Pre-Kindergarten Childcare

Head Start
State Provided Care
Center Care
Parental Care
Relative Care

Non-Relative Care