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Gazing Past the Gaps: A Growth-Based Assessment of the Mathematics Achievement of Black Girls

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Abstract The purpose of this study was to proffer the idea to "gaze" past gender and racial achievement gaps by providing a growth-based assessment of the achievement of Black girls. The study aims to elucidate how alternatives to traditional achievement gap analyses can yield information relevant to addressing classroom challenges. This exploratory analysis utilized effect sizes and confidence intervals to summarize the achievement of Black girls in mathematics across fourth and eighth grade NAEP assessments. This approach was selected because it supports meta-analytic thinking, which is important for comparison and generalization across studies. The results of this quantitative single-group summary of NAEP data indicated that Black female students demonstrated performance contrary to popular results for female students in general. Fourth grade Black girls demonstrated growth in *Number and Operations* and *Algebra* and solid performance in *Measurement* across time. While statistically significant growth across all mathematics subject matter was observed for eighth grade Black girls. This study contributes to the

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literature on intersectionality and achievement by extending both lines of inquiry. Intersectional research rarely investigates student achievement with a quantitative lens, while achievement research traditionally utilizes a between group comparative approach. The practical and empirical implications of these research extensions are provided in the discussion.

Keywords Black girls · Mathematics · Academic achievement · NAEP · Achievement gap

Introduction

All too often research comparisons are selected to maximize difference to ensure statistically significant results. These comparisons are common in the published literature, and there is little comment on within-group analyses. Specifically, the needs of White girls and Black boys are often used as a proxy for intersectional research at the crossroads of race and gender—namely Black girls. Similarities exist across all three groups, but distinctions are equally present. For example, the mathematics achievement of Black girls diverges from the traditional mathematics gender achievement trends in K-12 settings.

Black girls consistently outperform Black boys in mathematics (Young et al. 2017b; McDaniel et al. 2011). However, these differences are often small, thus the studies often lack the statistical power to detect these differences (Young et al. 2017a; Mickelson and Greene 2006; Kerpelman et al. 2008). Historically, the mathematics gender gap has favored male students. These differences are more prevalent and noticeable in the most advanced mathematics courses in K-12 (Else-Quest et al. 2010). Recently, more findings are indicating that gender parity in mathematics achievement is imminent (Cheryan 2012; Kane and Mertz 2012). Given the divergent results provided by gender and racial comparative studies, a nuanced examination of Black girl mathematics performance is instructionally and empirically important. Yet, a single group summary of Black girl mathematics achievement is nearly absent from the literature.

Student achievement is commonly analyzed using between or within-group analytic structures. Critical multicultural scholars propose within-group, rather than between-group analyses because of the numerous benefits one can acquire when data are disaggregated by gender, race, language proficiency, and socioeconomic status (Young and Scott 2016; Rios-Aguilar 2014). One benefit of this approach is that more of a group's internal variability can be examined (Carter and Hurtado 2007). This is important when working to improve the quality of instruction for traditionally marginalized populations of learners, because with this approach comes a greater understanding of the variations within the population of interest. This common preoccupation with gap analysis can be defined as "gap gazing".

Gutiérrez (2009) defines gap gazing as the prevailing discourse in the United States that overemphasizes a closing the gap mentality in which comparisons are made between Asian and White students and their Black, Latina/Latino, and Native

American counterparts. Gap gazing is recognized across many subject matter areas, but has received considerable attention in mathematics education (Lubienski 2008). Gap gazing is problematic because focusing on the measurement of group differences rarely yields information that can be translated into classroom practices to improve learning. This is prevalent when analyses fail to take into account established performance standards, or perpetuate racial achievement hierarchies. For instance, most achievement tests utilize “cut-scores” that are used to identify the students’ level of performance on the exam. However, the score interpretations are rarely discussed in the achievement gap literature. Overall, analyses based on gap gazing often fail to provide sufficient contextual information to present a complete and balanced representation of the achievement of traditionally marginalized populations of learners. This discourse is partially responsible for the dearth of empirical research on Black girls (Larke et al. 2016a).

There are several explanatory flaws inherent in gap gazing. The first common flaw is its dependence on one-dimensional measures of achievement, assessed at a single point in time. The assessments often lack the design and measurement specificity to influence a change in student outcomes. Another common flaw is the choice of comparison group, which often lacks adequate matching. Groups are often assumed to be matched when students are in the same class or school. The obvious argument is that students in the same school or class are comparable; however, nothing can be farther from the truth. Typically, students of color in the same school as White and Asian students experience high levels of poverty, less parental engagement, and fewer extramural or informal educational opportunities. Finally, the validity of comparison group analysis suffers from the most grievous flaw that of perpetuating stereotypes. The research perpetuates stereotypes through methodologies that make use of readily accepted practices that do not meet the most common bars for replicability and generalizability. For example, White students are historically chosen as the comparison group across many studies even though Asian students typically outperform White students on many mathematics assessments (Martin 2009). Thus, these methods implicitly encourage the perpetuation of ideals that suggest that certain groups are performers of mathematics, while others are not. At best, comparison studies can show that students of color are as capable as the enfranchised group; however at their worst, they reify that lack of potential for success in mathematics for students of color. Alternatives to gap gazing and achievement gap perspectives are more than judicious - they are obligatory.

The National Assessment of Educational Progress (NAEP) is one of few large-scale assessments of mathematics achievement with the breadth of data to assess within-group differences. Yet, much of the published literature on mathematics achievement measured by the NAEP focuses on between, rather than within-group performance. Some argue that when between-group analyses are conducted there is an implicit assumption that the differences between groups are the same as the differences within groups (Gutiérrez 2008). This assumption is especially detrimental to the advancement of knowledge that supports the mathematics achievement of Black girls. NAEP scale scores consistently show that Black students underachieve in mathematics as compared to other groups. Therefore, Black girls as members of this group must also underachieve. More generally, the existing gender gap literature on the NAEP favors boys; consequently, Black girls' performance often goes undocumented and underrepresented in the literature.

Racial Achievement Gap

According to the National Research Council (2004), the achievement gap is the disparity in achievement between White and non-White students. The disparity is present in standardized test scores, grade point averages, graduation rates, and college admission data. For the purpose of this discussion, the focus is placed on research examining the Black–White achievement gap. The gap starts in the early grades and grows over time. For instance, Bali and Alvarez (2004) concluded that the Black–White achievement gap originates before the first grade and increases as students progress from grade to grade.

The factors associated with the persistence of the achievement gap are multifaceted. According to Coleman et al. (1966), schools with more affluent White students have higher achievement even after statistically controlling for race and social class. Thus, two sets of factors are commonly examined within the Black–White achievement gap literature: (1) out of school factors and (2) school-related factors. Barton and Coley (2007) assessed 16 factors—7 were school-related, 8 out of school, and the final factor was parent participation in school activities. Examples of out of school factors included birth weight, lead exposure, and excessive television exposure. Some examples of the school-related factors were curriculum rigor and teacher preparation. Given that teachers are responsible for many school-related factors, scholars are currently working to alter the discourse of achievement gap research.

Opportunities to learn are essentially the structures, resources, programs, instruction, and other educational inputs that many Black students from urban schools traditionally do not receive (Young and Young 2017). These structures are the impetus to instructional and achievement change in urban schools. Opportunities to learn are absent from many classrooms serving large populations of culturally and linguistically diverse students (Boykin and Noguera 2011; Darling-Hammond 2010; Delpit 2012; Howard 2010). These opportunities include school-related factors such as teacher quality, rigorous curriculum, student academic engagement, and high expectations. The absence of these opportunities can hinder the ability of students of color to reach their full educational potential. Ladson-Billings (2006) asserts that an "education debt" or unfulfilled educational promise has accumulated overtime creating a disadvantage for Black students and other traditionally marginalized populations. This debt is recorded historically in the funding and policies that undermine the academic success of students of color. These are some of the many challenges and impediments that influence Black girls.

Gender Achievement Gap

Disparities between girls and boys have been documented for more than 30 years. Historically, gender achievement gap research is more extensive in the mathematics and science content areas (Halpern et al. 2007; Wai et al. 2009) than for other areas. For instance, mathematics studies throughout the 1970s and 1980s conclude that boys outperform girls after ninth grade (Fennema and Carpenter 1981; Fennema and Sherman 1977). Other evidence supports the notion that gender performance differences in mathematics are influenced by the measurement and type of mathematics content assessed (Hyde et al. 2008; Mendes-Barnett and Ercikan 2006; Taylor and Lee 2012). For instance, in an examination of national and international performance on the Programme for International Student Assessment (PISA), Liu and Wilson (2009) posit that a small, but consistent male advantage existed on complex mathematics assessments. Subsequently, a large body of research supports the notion that male students outperform their female counterparts.

A growing number of scholars believe that the gender gap has significantly narrowed, although the results are not univocal. Therefore, some have made claims that the gap has closed or is negligible (Frieze 2014; Lindberg et al. 2010; Robinson and Lubienski 2011). These studies suggest that the mathematics achievement of girls is on the rise. However, few studies have disaggregated the mathematics achievement data by race and gender to examine the intersections between these demographic categories (e.g. Larke et al. 2016b). Thus, despite evidence of gender achievement disparities, many scholars believe that more work is needed to assess the gender gaps across racial groups (Hyde and Mertz 2009).

Identifying as both Black and female, Black girls can be dually marginalized mathematics learners. Dual Marginalization refers to the “double” or interactional marginalization that occurs when a person is negatively affected by being a member of two marginalized populations (Young et al. 2017c). Given the dual marginalization of Black girls by race and gender, it is important that scholarship captures their nuanced mathematics performance. Black girls represent an important population within society. They are indistinctively situated in the achievement gap literature because they do not typically straddle the fence of disparity; rather they are representatives of two groups that are traditionally perceived as underachieving in mathematics. Therefore, little is known about the achievement of Black girls in mathematics.

The Mathematics NAEP

The NAEP represents the nation’s report card and consistently reports the gender and racial mathematics achievement gaps every 2–3 years for grades 4, 8, and 12. Since the late 1960s, the NAEP has been the only nationally representative and continuing assessment of American students across subject areas.

The NAEP Instrument

The NAEP mathematics subtest consists of two assessments. The first assessment is the Long-Term Trend (LTT) analysis, which is the oldest assessment, but does not reflect current mathematics education standards. The LTT has only received minor adaptations over the years because it is designed to assess generational differences in mathematics content knowledge. The focus of the current study is the main NAEP assessment, which has been consistently updated and aligned to curriculum and reform practices over the last 40 years. Furthermore, the main NAEP has seen more variation in question formats and delivery options based on changes in educational theories and NCTM standards (Innes 2012). To avoid confusion, the remainder of this discussion will use the term NAEP to describe the main NAEP not the LTT analysis.

The NAEP samples hundreds of thousands of students each year. The samples are large enough to be considered representative samples for each of the 50 states and pertinent U.S. territories. This sample magnitude allows researchers to examine achievement gaps between and within individual states and the nation (Vanneman et al. 2009). Traditionally, NAEP assessments are conducted in a six-week window starting in January of each assessment year. The NAEP scale scores are scaled 0–500 or 0–300 (NCES 2011a). Based on these scales, achievement levels were established and implemented for interpretative purposes. The NAEP achievement levels are *Basic*, *Proficient*, and *Advanced*. Using this structure as an explanatory guide, the trends in the Black–White achievement gap are presented in the next section.

Black–White Achievement Gap Trends

The NAEP is one of the oldest and most utilized assessments to measure and interpret the Black–White achievement gap. These trends are so well established in the culture of NAEP that National Center for Educational Statistics (NCES) has a conventional definition of the achievement gap related to this data. The NCES (2013) defines the educational achievement gap as “the achievement gap that occurs when one group of students outperforms another group, and the difference in average scores for the two groups is statistically significant” (p. 210). According to NCES, despite a persistent statistically significant difference between Black and White scale scores, the non-standardized differences have decreased each year (Lee et al. 2007; NCES 2009, 2011b). Additionally, Rindermann and Thompson (2013), converted NAEP scores to IQ equivalents and concluded that the NAEP data suggest that the ability gaps between White and Black students were shrinking. However, others claim the gaps in mathematics achievement are far from diminishing.

In fact, some argue that the gap is persistent. Harris and Herrington (2006) suggest that the Black–White NAEP mathematics achievement gap has remained large and statistically significant since the inception of NAEP and has remained virtually stagnant since 1990. Furthermore, according to Krull (2014), the NAEP data also indicated that over the last 40 years, change in the rate of achievement for

Black students was negligible. Despite the allusion of conflicting results, most understand that the mathematics achievement gap measured by the NAEP is enduring and relatively consistent. Yet, little evidence exists to substantiate the claim that achievement differences and rates were consistent across time for Black boys and girls. Hence, it is important to understand the presence and trends in the mathematics NAEP gender achievement gap to better ascertain the achievement of Black girls.

Gender Achievement Trends

The gender achievement gap was measured and presented in the Nation's Report Card with each NAEP administration alongside the Black–White achievement gap. Consequently, most U.S. examinations of the gender gap involved NAEP data (cf. Robinson and Lubienski 2011). Much of the research in the area often claimed that a male advantage exists on large-scale mathematics assessments such as the NAEP. For instance, an examination of gender differences on the 12th grade NAEP showed that males had consistently higher mean scale scores in mathematics (Cunningham et al. 2015). Unlike the Black–White achievement gap, the gender achievement gap was not as wide and was far less consistent. However, the trends have persisted for decades.

A small, but persistent gender disparity exists favoring males on the 4th, 8th, and 12th grade NAEP assessment, although these gaps were approximately a tenth of a standard deviation (McGraw et al. 2006; Reilly et al. 2015). The size of the achievement gaps between male and female students does not differ as it relates to consistent statistical significance, which garners more support for the notion that the gaps are closing. According to Geist and King (2008), NAEP data indicated that a gap of only 2 points has developed over the last decade of mathematics NAEP administrations. Despite promising progress in the area of the gender achievement gap, much of the available data lacks assessments of the intersections of both gender and race.

All too often datasets are not used optimally, but to perpetuate deficit thinking. For example, Reilly et al. (2015) conducted a meta-analysis of gender differences in NAEP performance from 1990 to 2011 on the mathematics and science NAEP, but did not analyze race as a moderator, despite access to representative samples of girls and boys of color in the dataset. This was only one of numerous examples of how the lack of disaggregated data by gender and race can impede knowledge accumulation. The trends in the Black–White achievement gap and the gender achievement gap were essentially divergent. The Black–White gap has remained large, while the gender achievement gap was relatively small. Because Black girls exist as both Black and female, they can be exposed to marginalization based on their gender and racial identity in the mathematics classroom. Despite this reality, data are not disaggregated to examine effects at the intersection between race and gender. Thus, it is important to better ascertain the within-group performance of Black girls, as the Black–White and gender achievement gaps yield little evidence specific to Black girl performance in mathematics.

Purpose

The National Assessment of Educational Progress (Bohrnstedt et al. 2015) is touted as the Nation's report card and has reported mathematics achievement gaps between Black and White students for decades. Subsequently, much of the literature associated with the "Black–White" achievement gap consistently cites results generated from NAEP assessments. It is perhaps this document and others like it that play a role in the incessant preoccupation with looking into the "great divide". Studies of between-group variance tend to employ a deficit-minded rather than a strength-based analysis of the achievement of children of color. Because of this, researchers have started to criticize the perpetuation of such studies while in search of strength-based analyses.

The purpose of this study was to proffer the idea to "gaze" past gender and racial achievement gaps, by providing a growth-based assessment of the achievement of Black girls. Therefore, a single-group summary of the 4th and 8th grade mathematics achievement of Black girls on the mathematics portion of the NAEP was conducted. A secondary purpose of this study was to present several benefits and unique analytical insights that single-group summaries afford researchers interested in Black girls' achievement. Through this study, statistical alternatives were suggested that can be used to avoid succumbing to the allure of between-group variance analyses that lead to the perpetuation of "Gap Gazing". An additional perspective presented through this research was the longitudinal performance trends of Black girls that will provide the historical evidence for what has or has not worked and to establish a trend line for comparison for studies yet to be designed. Thirdly, presented in this study were empirical, practical, and educational implications, which have been of great importance to historical research concerning the achievement of Black girls. To this end, the following research questions guided this investigation:

1. What are the 4th and 8th grade mathematics achievement trends of Black girls on the NAEP over the last decade of administrations?
2. What are the within-group mathematics achievement differences for 4th and 8th grade Black girls across administrations?

Method

This study was conducted in three steps. First, composite and individual 4th and 8th grade mathematics achievement scale score data were extracted from the NCES data management system. The achievement of Black girls was the unit of analysis for this study; thus, only female and Black student descriptive data were extracted. Data from 2005 until 2015 were included in the extraction process yielding 36 independent scale score point estimates extracted from five distinct content strand scales: (1) *Number sense, properties*, and *operations*, (2) *Measurement*, (3) *Geometry* and *spatial sense*, (4) *Data analysis, statistics*, and *probability*, and (5) *Algebra* and *functions*. The overall composite scale was also extracted.

Next, the data were cleaned and prepared for analysis. The data were organized and screened in Microsoft Excel prior to the analysis. An initial screening of the data was necessary to ensure data integrity. The screening process was conducted to ensure sufficient data were present in each administration of the NAEP to answer the research questions. Because additional survey items are added with each administration and others are removed, this was a necessary step in the data analysis process. The descriptive statistics and data retained from the initial screening were administration year, scale, sample size, mean scale score, and standard deviation of mean scale score. At this point, mathematics proficiency data were also extracted across all content scales from 2005 until 2015. These data included Black girls' scores within the following categories: (a) at or below basic, (b) at basic, (c) at proficient, and (d) at advanced. These data were collapsed into dichotomous categories of proficient and not proficient. This was done in preparation for the calculation of the odds ratios.

Analyses

To assess the achievement trends across administrations, line graphs were created in Microsoft Excel™. A separate line graph was created for the composite score, as well as each of the content specific scales. The point estimates for these plots were the mean scale scores plotted over the 10-year time span from 2005 until 2015. To assess the trends across scales, each scale was plotted on the same line graph, and distinctive markers were utilized to distinguish between scales and point estimates. This process was repeated for the 4th and 8th grade mean scale scores.

To assess performance overtime, mean difference effect sizes were calculated, using the 2005 scale score as the initial score and the 2015 scale score as the final score. Given the extensive sampling procedures utilized by NCES, one can assume that the 2005 and 2015 samples were independent; thus, the Hedges *g* effect size was calculated. Statistically significant differences were evaluated by examining whether or not the mean difference confidence interval included the value of zero. Effect sizes provide a quantitative description of the observed effect that goes beyond the identification of statistically significant differences, which can lack practical application (Capraro 2004; Fritz et al. 2012). In the present study, it was important to utilize an unbiased measure of effect size given the differences in sample sizes based on the NAEP sampling procedures. The Hedges *g* was most appropriate given its utilization of the pooled sample standard deviation (Hedges 1982). This process was also completed across individual scales and the 4th and 8th grade mathematics assessments.

Unlike the 12th grade assessment, the scale scores for the 4th and 8th grade girls remained consistent across administrations; however, given the differences in explicit content and proficiency cut scores, the researchers felt that it would not be appropriate to directly compare mean scale scores across grade levels. Furthermore, if the scores were normalized, much of the pertinent data represented in the scale of the score would be lost; thus, the researchers chose to examine the differences in proportion of mathematically proficient girls at each grade level. To assess the differences in mathematics proficiency across grade levels and to look for trends over time. The odds ratios were calculated and the 95% confidence intervals (CI) were plotted from 2005 until 2015. An odds ratio is a measure of the relationship between an exposure and an outcome. In the present study, we wanted to examine how exposure to more mathematics was associated with mathematics proficiency in Black girls. Odds ratios were calculated under the following assumption: if 8th grade girls received more mathematics instruction over time, they should by default become more proficient in mathematics. According to Szumilas (2010) odds ratios were interpreted as follows: $OR = 1$ exposure does not affect odds of outcome, $OR > 1$ exposure associated with higher odds of outcome, and $OR < 1$ exposure associated with lower odds of outcome. For the purpose of this study, odds ratios greater than 1.0 indicate that exposure to more mathematics increases the odds of mathematics proficiency while odds ratios less than 1.0 indicate that exposure to more mathematics lowers the odds of mathematics proficiency (Odds ratios greater than 1.0 favor 8th grade girls while those lower than 1.0 favor 4th grade girls). Chen, Cohen, and Chen (2010) suggest following magnitude benchmarks: odds ratios < 1.68 (small), 1.69–3.47 (medium), and 3.48–6.71 (large). Additionally, because mathematics proficiency is presented in four discrete categories, but odds ratios are dichotomous, the proficiency data were rescaled to the following: (a) at or below basic and (b) at or above proficient.

Results

4th and 8th Grade Black Girl Achievement Trends

See Table 1 for the mean scale scores across administrations. The scores indicated moderate improvement between each administration in most content areas in grades four and eight. From the 2013 to 2015 administrations, there was a drop in performance across all mathematics domains except 4th grade *Number and Operations* and 8th grade *Measurement*. The variability of performance in 4th grade across administrations was relatively consistent within each content domain; however, the measurement domain had consistently higher standard deviations than those of the other content domains. A similar pattern was present in the variability of the 8th grade performance across administrations and content domains. A score of 249 and 299 indicated mathematics proficiency on the 4th and 8th grade mathematics NAEP respectively; however, the average performance across administrations was consistently less than the aforementioned scores.

Various performance trends existed across 4th and 8th grade administrations and content domains. Performance trends in 4th grade were relatively similar from 2005 until 2009 as seen in Fig. 1. In *Geometry* the slopes were more positive between 2005 to 2007 and 2007 to 2009, which indicated larger growth in mean scale scores. From 2009 until 2015, the performance trends differed across content domains based on the changes in the steepness of the slopes between administrations.

Table 1 Mean Scale Scores Across Mathematics NAEP Administrations

	Year	4th grade		8th grade	
		M	*SD*	*M*	*SD*
Composite	2005	221.36	25.72	256.73	32.74
	2007	224.33	26.07	261.82	31.31
	2009	224.49	26.06	262.88	33.01
	2011	226.27	26.14	265.39	32.92
	2013	227.32	26.62	266.20	32.94
	2015	226.75	26.95	263.94	33.10
Algebra	2005	229.50	26.16	263.34	33.50
	2007	231.28	25.33	267.75	31.96
	2009	230.65	24.67	268.79	33.64
	2011	231.22	25.05	272.00	33.52
	2013	234.22	26.46	273.29	34.37
	2015	233.06	27.71	271.86	35.59
Data	2005	227.27	25.69	259.32	37.78
	2007	229.20	26.67	265.89	36.33
	2009	228.61	27.57	264.47	39.20
	2011	229.20	27.70	268.20	39.22
	2013	228.16	28.26	268.43	39.99
	2015	224.56	28.45	262.19	40.64
Geometry	2005	223.04	23.18	256.07	31.53
	2007	227.01	23.32	260.92	30.36
	2009	228.32	24.19	261.64	32.13
	2011	230.91	23.82	264.40	32.58
	2013	230.43	24.60	266.43	31.52
	2015	225.76	24.02	262.32	31.91
Measurement	2005	216.56	30.19	244.99	43.57
	2007	219.49	30.82	251.15	42.48
	2009	220.00	31.55	253.07	43.69
	2011	219.84	31.71	254.18	44.48
	2013	220.46	32.69	256.16	43.70
	2015	220.33	33.65	257.19	43.73
Number	2005	218.61	28.59	254.32	34.39
	2007	221.92	28.89	258.79	33.06
	2009	221.96	29.44	261.40	34.73
	2011	225.17	28.91	262.75	33.57
	2013	226.78	29.41	261.22	33.77
	2015	228.52	30.25	260.08	33.17

Performance on 4th grade *Measurement* was consistently lower than the other mathematics content areas, and the slopes were relatively flat which indicated that there was a small but steady increase over time. The data in Fig. 1 suggested that

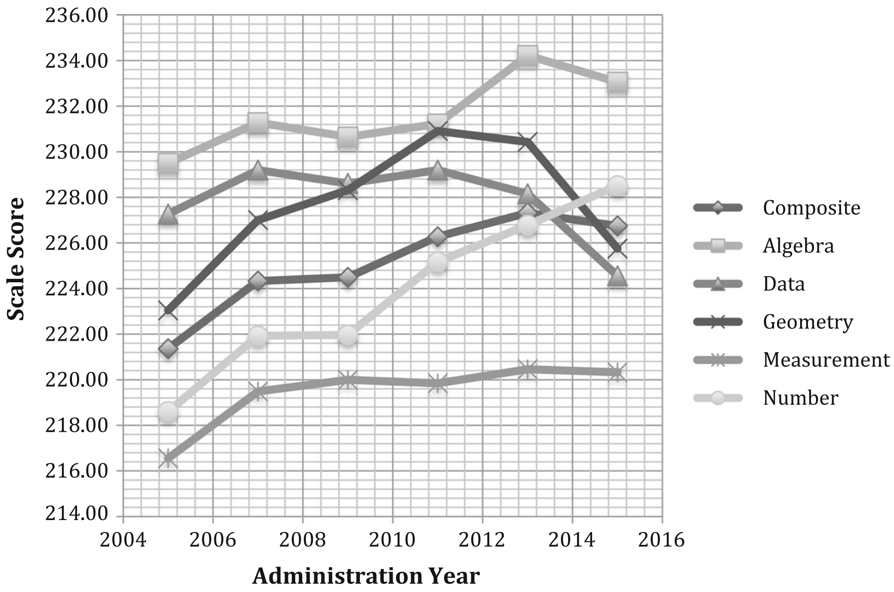

Fig. 1 4th grade performance trends across 2005–2015 administrations

performance was strongest in *Algebra* given its position above the other content domains. *Algebra* performance was inconsistent from administration to administration with small increases followed by small decreases. From 2011 to 2013, the slope was the steepest, which suggested that student performance increased the most in *Algebra* during this timeframe. Performance in *Number* showed a consistent positive increase after 2009, and was the only domain not showing a decrease from 2013 to 2015. The composite or overall scores increased slightly but consistently after 2009 until the decrease from 2013 to 2015.

Figure 2 suggested that 8th grade performance trends were more similar across domains and administrations. Across administrations performance tends to rise and fall at similar points in time; however, the rates of change were not consistent.

Contrary to plots in Fig. 1, the plots in Fig. 2 suggested that student performance on *Data Analysis and Probability* was consistently higher than performance in other content domains. The trends in performance provided incremental evidence to help understand the growth from administration to administration, but the overall mean differences between 2005 and 2015 provided a summative assessment of the overall performance. *Measurement* was at the bottom of Fig. 2, which suggested that students underperformed in 8th grade measurement.

The data in Table 2 indicated that there was an overall statistically significant increase in performance from 2005 until 2015 based on the standardized mean difference effect size for the composite scores. Standardized mean differences ranged from − .103 to .342 standard deviations.

All 4th grade mean differences were statistically significantly different from zero based on the exclusion of zero in the 95% CI. There was a decrease in performance in *Data Analysis and Probability*. It was important to note that although mean scale

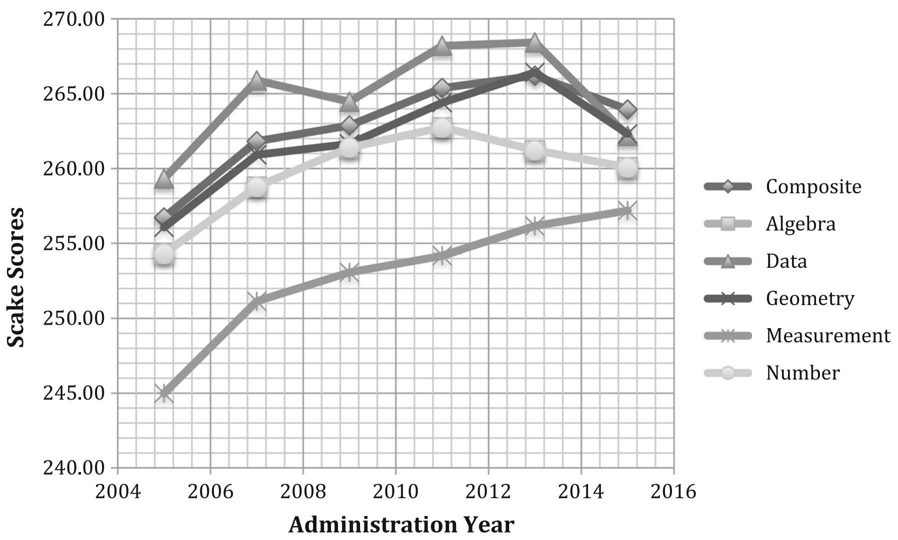

Fig. 2 8th grade performance trends across 2005–2015 administrations

Table 2 4th grade mean difference scores from 2005 to 2015 mathematics NAEP administrations

	Δ	*d*	95% CI	
Composite	5.39	.21	.18	.24
Algebra	3.56	.13	.10	.167
Data	− 2.71	− .10	− .14	− .07
Geometry	2.72	.12	.08	.15
Measurement	3.77	.12	.09	.16
Number	9.91	.34	.31	.38

scores were highest across administrations for *Algebra*, it did not have the highest growth—rather *Number and Operations* had the largest increase of almost 10 points on the NAEP performance scale. In 8th grade the overall performance statistically significantly increased .219 standard deviations, compared to the .207 standard deviations increase in 4th grade. However, across all content domains in 8th grade there was a positive statistically significant increase in performance from 2005 to

Table 3 8th grade Mean Difference Scores from 2005 to 2015 Mathematics NAEP Administrations

	Δ	*d*	95% CI	
Composite	7.22	.22	.19	.25
Algebra	8.52	.25	.22	.28
Data	2.87	.07	.04	.10
Geometry	6.24	.20	.17	.23
Measurement	12.20	.30	.25	.31
Number	5.77	.18	.14	.20

2015. The largest increase was in *Measurement*, while the smallest increase was in data analysis and probability (see Table 3).

Within-Group Achievement Differences

To examine differences between mathematics proficiency in grades four and eight, odds ratios (OR) were calculated using 4th grade as the base line and 8th grade as the experimental. All ORs from 2005 until 2015 were less than 1, which indicated that 8th grade Black girls were less likely to score at the proficient level on the NAEP. Based on the lack of overlap between confidence bands from 2005 until 2015, the results were relatively consistent across the observed NAEP administrations (see Fig. 3).

Limitations

This study has several strengths and limitations. First, this dataset is large, representative, and familiar. This is empirically and practically noteworthy. The empirical strength of the dataset lies in the NAEP sampling protocols, which by design include representative samples of racially and ethnically diverse participants (Bohrnstedt et al. 2015). This is important because samples observed across administration are representative of the Black girls in grades four and eight from multiple locations across the United States. This is an important consideration given the research on school demographic characteristics and Black student achievement (Aud et al. 2010; Ogbu 2004). Because the NAEP solicits students from a variety of diverse schools with unique demographic characteristics, the participants represent various school settings. The results were practically significant because the NAEP

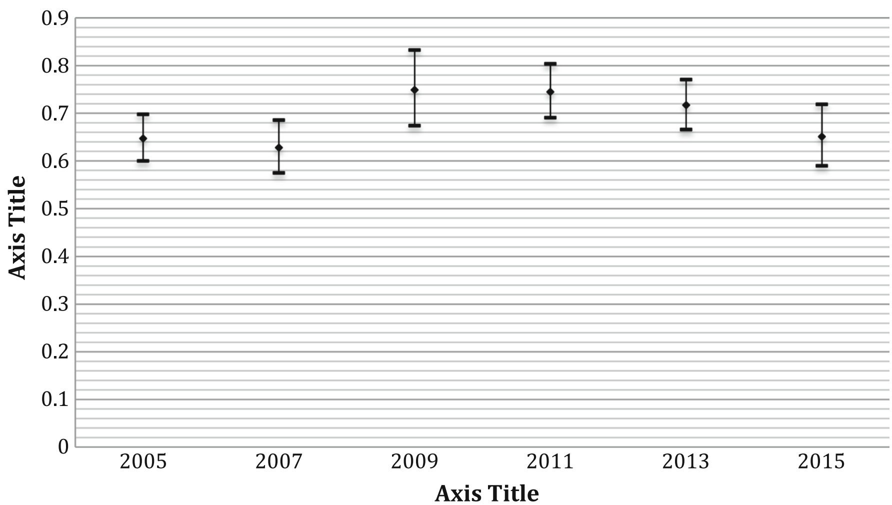

Fig. 3 95% confidence intervals for odds ratios

represents the nation's report card; thus, thus its results have a rich history in educational research, which contributes to its familiarity amongst researchers and classroom teachers.

A limitation of this study is the inability to reasonably include the data from the administrations with 12th grade Black girls. The scaling and design of the 12th grade assessment has evolved and been altered repeatedly. Specifically, after the changes to the 2005 framework, later scores were no longer comparable to scores on the 4th and 8th grade exams (NCES 2010). This prevented the construction of comparable confidence interval plots overtime. Thus, drawing parallels at this point is not empirically reasonable and would jeopardize the practical interpretation. The inclusion of the 12th grade data would provide information about Black girls at three critical points in the K-12 educational trajectory; nonetheless, this study provides a thorough characterization of the mathematics achievement of Black girls in grades 4 and 8.

Discussion

The purpose of this study was to proffer the idea to "gaze" past gender and racial achievement gaps, by providing a growth-based assessment of the achievement of Black girls. A secondary purpose was to present this summary from the perspective of a strength-based growth focus. This perspective acknowledges the presence of challenges, while seeking to promote growth by citing and affirming strengths as a means to build capacity and promote success. Based on the results of this study, 4th grade Black girls had a statistically significant improvement from 2005 until 2015 overall, and in every domain except *Data Analysis and Probability*. This result provides an alternative to the traditional analyses and interpretation of Black student performance on the mathematics NAEP. Historically, Black student data has been presented within the context of the achievement gap while intersections between race and gender have not been presented in the standard NAEP mathematics report (Barton and Coley 2010; NCES 2011c).

The observed scores for *Data Analysis and Probability* suggest that the performance for Black girls was statistically significantly lower in 2015 compared to their performance in 2005. Many posit that given a dramatic score decrease in *Data Analysis and Probability* across subgroups on the 2015 NAEP, other factors beyond the student should be considered when interpreting this result. Codding, Mercer, Connell, Fiorello, and Kleinert (2016) analyzed student performance data on the 2015 administration of the mathematics NAEP and the Massachusetts Comprehensive Assessment System (MCAS) and found that despite strong correlations between the examinations and their alignment to the Common Core, other factors needed to be considered given the results from other states. This information further substantiates the need for an additional investigation into score irregularities in the 2015 administration.

The overall mean difference effect size for the mathematics composite score was .21 standard deviations, which was statistically significant. While effects are often difficult to interpret in the absence of prior similar studies, one can make general assumptions regarding their importance. In this case, the .21 standard difference accounts for a positive 16% increase, which is an important result when considering test performance. Within each domain, the effect sizes were all approximately .10 standard deviations or less, except for *Number and Operations*. On *Number and Operations,* Black 4th grade girls' mean growth was moderate and represented a relative area of strength. The .35 effect size was more than twice as large as the effect sizes observed for other domains. Overall, the observed growth was relatively consistent despite challenges in the area of *Data and Probability* based on the negative mean difference effect size. These results provide an additional perspective to current evaluations of mathematics achievement differences within gender and race. For example, Robinson and Lubienski (2011) examined gender gaps across racial groups and found that a statistically significant mathematics achievement gap of .24 standard deviations exist between male and female students, favoring male students. However, the present investigation evaluates growth overtime, thus providing an additional lens to guide instruction and policy.

Black girls' performance on the 8th grade NAEP statistically significantly increased overall and across all domains. Effect sizes ranged from .07 to .30, or from not very noteworthy to noteworthy. Similar to the performance of 4th grade Black girls, gains on *Data Analysis and Probability* were the smallest, and represented a challenge in 8th grade. *Measurement* on the other hand, had the largest standardized mean difference effect size observed. This is important because *Measurement* is recognized as a challenge across many middle school mathematics assessments (Tsuei 2012). This further substantiates the need to disaggregate mathematics assessment data to consider specific cases within classifications. In a qualitative study using an interpretive design with multiple data sources Pringle et al. (2012) found that many teachers struggle to perceive Black girls as mathematics achievers, and tend to position them in a negative academic context more consistently. However, the present study directly positions Black girls as mathematically competent with consistent and noteworthy growth.

Performance trends overtime suggested that Black girls' mathematics knowledge, measured by the NAEP, varied in magnitude and was inconsistent across domains. These trends suggested that algebra was an area of strength for 4th grade Black girls, while *Data Analysis and Probability* showed the greatest increase for 8th grade Black girls through 2015. Subsequently, despite representing a consistent strength in 4th grade for Black girls, *Algebra* was a consistent challenge in 8th grade. In both groups, measurement was an area of concern that required further investigation despite substantial longitudinal gains in 8th grade. Finally, the results of this study indicated that 4th grade Black girls were more likely to be mathematically proficient compared to 8th grade Black girls based on a comparison of odds ratios from 2005 until 2015. This indicated that based on the observed timeframe and NAEP data the likelihood of a Black girl being mathematically proficient did not increase after 4th grade. Prior research suggested that early mathematics achievement in students was strongly related to future achievement in mathematics and other content areas (Claessens and Engel 2013; Jordan et al. 2010). The data in this study took a slightly different approach. Here we compared the mathematics proficiency of 4th grade Black girls to 8th grade Black girls.

Nonetheless, the results of this study are similar to that of prior work that suggests that mathematics growth rates are more of a concern for Black students than achievement gaps (Capraro et al. 2009).

Benefits of Single-Group Summaries

In summary, these results provide a unique analytical perspective to the achievement research literature. This perspective provides the following empirical, practical, and educational implications. First, Black girl achievement was analyzed within, rather than between groups. This is important because performance differences represent growth rather than achievement gaps based on normative analytical models. This is a critical empirical implication because it provides an example of one possible alternative to between-group achievement gap analyses. These types of within-group analyses can help change the discourse surrounding Black student achievement by providing strength-based and growth oriented approaches to data analysis.

Secondly, trends across mathematics subject matter provide practical data of educative importance that can be used to inform classroom practices. The data trends provide researchers with explicit and consistent areas of strength and challenges that can be addressed in the classroom. These types of practical data are often absent from many traditional approaches to data analysis. Between-group differences are less practically relevant because they fail to place the standard in the forefront of the discussion. When we fail to compare student performance to the standard, we essentially fail all students. Additionally, these data support meta-analytic thinking, which has important educational implications that can provide important baselines and benchmarks to examine change over time and estimates for the magnitudes of the effect.

Meta-analytic thinking can be defined as the contextualization of study designs and results by examining the effects of prior research. This process is important because outside of direct replication, this can potentially advance social science research by helping to increase the comparison of results overtime (Cumming and Finch 2005; Henson 2006). This practice is especially necessary to inform research concerning the teaching and learning of Black children. Historically, much of what is considered best practice in mathematics education is based on homogenous populations of students often representative of the dominant cultural norms. As more research is conducted with Black students in mathematics spaces a more nuanced perspective of "culturally responsive" practices can emerge as study results are aggregated and compared overtime. These results can provide the instructional information necessary to address knowledge gaps rather than achievement gaps in mathematics and other subject areas.

Conclusion

The results demonstrate that data, when analyzed by standard practices, hide important information. Black girls perform contrary to what some might consider common knowledge. For example, across the United States, their performance in *Measurement* trended up, and on international comparisons *Measurement* skills are typically weak. Some researchers have argued that *Number Sense and Operations* are as important as *Algebra* for post-secondary success (Capraro et al. 2014). Given that the "hidden" STEM workforce is high-paying, but often requires 6 months to 2-years of post-secondary training, (Olson and Labov 2014, President's Council of Advisors on Science and Technology 2012) fluency in *Number and Operations* functions as the gatekeeper for the "Hidden" STEM workforce, just as Algebra does for a college degree (Usiskin 1987, 1995). When considering the stark improvement in algebra skills, it appears that Black girls are also achieving dramatic improvements in algebra that would seem to be aligned with their college readiness. In conclusion, by gazing past the gaps it is possible to better ascertain a more holistic characterization of the mathematics achievement profile of Black girls that can be extended to other content areas and traditionally marginalized populations of interest.

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