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ORIGINAL PAPER

African Americans and Mathematics Outcomes on National Assessment of Educational Progress: Parental and Individual Influences

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Abstract This study investigated within group differences between African American female and male students who participated in the 2009 National Assessment of Educational Progress mathematics assessment. Using results from participating states, we compare average scale scores of African American students based on home regulatory environment and interest in mathematics. Results indicated that African American male students who discussed studies 2–3 times a week scored higher than African American female students who discussed studies every day. In three states (Connecticut, Florida, and New Jersey), African American males who never or hardly ever discussed studies at home scored higher than African American males who never or hardly ever discussed studies at home in the state of Arkansas. In two states (Florida and New Jersey), African American males who discussed studies every few weeks scored higher than African American males who discussed studies every few weeks in Arkansas. In four states (Connecticut, Florida, Illinois, and New Jersey), the overall scale scores of African American males was higher than those of African American males in Arkansas. As a result of the findings, we present practical implications for parents of African American students.

Keywords African Americans · Mathematics · Parents · NAEP · Mathematics education outcomes

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Introduction

Discussions concerning America's ability to compete globally, both economically and educationally, have ignited growing concern (Anderson and Kim 2006; Brophy et al. 2008). One outcome of the angst over competitiveness has been an increased interest to improve education in the areas of science, technology, engineering, and mathematics (STEM) (Callan 2006; Wagner 2006), particularly among students of color (Hirschman and Hrabowski 2010; Maton et al. 2009; Palmer et al. 2010). Hrabowski (2003), one of the leading authorities on increasing participation in science and mathematics among underrepresented youth, has argued that our "… nation will need to produce more minority scientists and engineers both to meet the increased demand and to address the underrepresentation of minorities in these fields" (p. 44). To do this, schools and educators have to address the following challenges: "stimulating the interest of minority students in math and science and preparing them to succeed academically in these fields" (Hrabowski III 2003, p. 44).

Historically there has been a lack of research examining the mathematical experiences of ethnic minority students (Lubienski and Bowen 2000). A disproportionate body of research positions African American students as deficient, underachieving, unmotivated learners with inferior skills when compared to their White and Asian peers (Ladson-Billings and Tate 1995; Reyes and Stanic 1988; Tate 1997). Positioning African American students in this manner perpetuates negative and often unfounded stereotypes that failure among African American students is the norm (Martin 2009; Moses-Snipes and Snipes 2005). Conversely, there is another body of research that seeks to counter this negative portrayal of African American students (Berry et al. 2011; Moore et al. 2003; Noble 2011;

Russell 2005; Thompson and Lewis 2005; Tucker et al. 2010). African American students face a range of challenges and successes as they develop as learners and doers of mathematics. Some factors influencing the mathematics achievement of African American students include parental and student dispositions.

Research indicates that African American students benefit from parental involvement (Berry et al. 2011; Hrabowski et al. 1998; Martin 2000; Moody 2000). High levels of parental involvement make it more likely for students to attend school, do their homework, and improve their language skills (Jeynes 2005). Parents serve as a source of motivation for students and their involvement makes a difference in African American students' mathematics performance and gains in performance (Muller 1998; Berry 2008); even if parents have a limited education (Slaughter-Defoe 1991). When studying the mathematical experiences of high achieving male college students, Hrabowski et al. (1998) found that parents exposed their sons to educational resources that fostered mathematical and scientific thinking, advocated to have students placed in the appropriate classes and to receive mathematics enrichment, and encouraged them to pursue mathematics careers.

The foundation for pursuits in mathematics begins at home. Home environments abounding with interesting activities have the potential to motivate children to engage in those activities and acquire new information (Schunk et al. 2008). Some home factors that have been shown to positively influence student achievement include mother's involvement with the child and opportunities for daily stimulation (Schunk et al. 2008). In a longitudinal study that explored the relationship between cognitive stimulation at home and children's academic motivation, Gottfried et al. (1998) assessed several home environment variables, which included library visits and importance of reading. Results indicated that greater cognitive stimulation led to higher academic motivation, and socioeconomic status had an indirect effect. While these results were for children ages 9–13, home environment also influences children at later ages when peers more strongly influence behaviors (Schunk et al. 2008).

It has been suggested that interest, defined as "liking and willful engagement in a cognitive activity" (Schraw and Lehman 2001, p. 23), plays some role in African American students' mathematics performance. Interest informs an activity's utility value (Rueda et al. 2008) as well as a person's ability to learn (Schunk et al. 2008) and subsequently impacts motivation (Eccles et al. 1998). Schunk et al. (2008) assert that people will perform successfully or learn when interested and will perform unsuccessfully or will not learn if uninterested. One could argue that African American students do not perform well in mathematics because they are not interested in the subject; on the other hand, one could also argue that they are not interested because they do not perform well. Additionally, they could not be interested as a result of their parents' lack of interest in the subject.

There has not been much research conducted on group differences in interest or its development over time (Schunk et al. 2008). Furthermore, there is a necessity for research on gender differences in personal interest (Schunk et al. 2008). A few studies have mentioned the interests of African American students and how their interests relate to their academic achievement (Long et al. 2007; Rueda et al. 2008); however, these studies did not focus solely on African American students. We contend that with a deeper understanding of the relationship between mathematics performance and interest of African American students, it is possible to design and implement educational policies and practices that will impact the mathematics literacy of these learners, thereby influencing their participation and achievement in advanced mathematics courses, leading to increased readiness for college and increased participation in STEM fields.

This study seeks to fill a void in the literature by examining within group differences of academic achievement, home environment, and individual disposition for African American students. In particular, using data from the National Assessment of Educational Progress (NAEP), we examined the following relationships: (1) African American students' mathematics achievement and home regulatory environment and (2) African American students' mathematics achievement and interest in mathematics. To meet this goal, we proposed the following research questions:

1. In looking at Black or African American 12th graders who participated in the NAEP assessment, are differences between students' mathematics average scale score impacted by home regulatory environment?
2. In looking at Black or African American 12th graders who participated in the NAEP assessment, are differences between students' mathematics average scale score impacted by personal interest?

Methods

Overview

Data for this study comes from the 2009 NAEP mathematics assessment. This assessment is used to evaluate the mathematics content American students are expected to know and can do (National Center for Education Statistics, n.d.) and is considered an "important tool for monitoring mathematics achievement gaps" (Lubienski 2002, p. 269). We did not use the NAEP Long-Term Trend study because

Main NAEP trend assessments after 2000 used a framework that is not comparable to NAEP Long-Term trends (Beaton and Chromy 2010). In the main assessment, overall scale scores are reported, but vary by grades. Scores for grades 4 and 8 are reported on a scale of 0–500 while grade 12, beginning in 2005, is reported on a scale of 0–300. In addition to overall scale scores, proficiency levels (basic, proficient, and advanced) and scale scores for each strand—algebra; data analysis, statistics, and probability; measurement and geometry; number properties and operations—emphasized by the National Council of Teachers of Mathematics (2000) are also reported. Included were data from 12th grade mathematics assessments as well as surveys administered to all participating students. Given our interest in the influence of home environment and personal interest on academic achievement, our independent variables were home regulatory environment and interest. The dependent variable was NAEP mathematics average scale scores.

Analytic Techniques

To explore the relationships between African American students' mathematics achievement, home regulatory environment, and personal interest, we used the web-based NAEP Data Explorer tool at http://nces.ed.gov/nationsreportcard/naepdata/dataset.aspx. This tool allowed us to analyze within group differences for African American males and females. This tool conducts significance tests using the false discovery rate (FDR) procedure to determine if the changes between two results are significant at the $p < 0.05$ level.

Participants

The 2009 12th grade sample information is provided in Table 1. Participation in the NAEP assessment is voluntary, and the number of participating states at grade 12 is relatively small.

Table 1 2009 12th Grade NAEP participation

States	*N*	African American (%)	*n*	Male African Americans (%)	Female African Americans (%)
Arkansas	2,700	22	594	48	52
Connecticut	2,800	13	364	52	48
Florida	3,200	20	640	44	56
Idaho	3,000	1	30	77	23
Illinois	2,700	16	432	49	51
Iowa	2,600	4	104	59	41
Massachusetts	2,900	8	232	53	47
New Hampshire	2,100	1	21	75	25
New Jersey	3,100	17	527	54	46
South Dakota	2,600	2	52	71	29
West Virginia	3,000	4	120	57	43

N students assessed, *n* African American students assessed

Table 2 NAEP scores and boundaries

	Male	Female
Average scale score	134	133
SD	31	29
Below basic	59 %	62 %
At basic	32 %	32 %
At proficient	8 %	6 %
At advanced	*	*

SD standard deviation

* Rounded to zero

Results

Recall that at the 12th grade level on the NAEP mathematics scale, scores range from 0 to 300. A minimum score for performance, called a cut score, is given for each achievement level. A cross-section of educators and "interested citizens" determine the standards for content knowledge. Then the National Assessment Governing Board accepts cut scores delineating the advanced, proficient, and basic boundaries. Therefore, a student whose average scale score exceeds 216 is considered advanced, which means that they should be able to demonstrate in-depth knowledge of mathematical concepts and procedures. A student whose average scale score exceeds 176 is considered proficient, which means that they should be able to select appropriate strategies to solve problems. Additionally, they should be able to integrate different concepts and procedures. A student whose average scale score exceeds 141 is considered basic, which means that they should be able to solve math problems involving direct application of concepts and procedures.

The national average scale score for African American students is 133 (SD = 30). Based on this scale score, 60 % of African American 12th grade students are below basic, 32 % are at basic, and 7 % are at proficient (percentage at advanced rounded to zero). In Table 2, descriptive statistics are provided for African American male and female students.

Research Question 1

Regarding research question 1 (Are differences between students' mathematics average scale score impacted by

home regulatory environment?), we examined differences in average scale score based on students' gender and the frequency that they discussed their studies at home, which is self-reported. We also examined differences in average scale score based on state of residence and frequency that studies were discussed at home.

The most significant differences occurred with the national sample where male students who discussed studies 2–3 times a week had a scale score 9 points higher ($p = 0.0020$) than female students who discussed studies every day. Across states of residence, there were only a few significant differences. For males who never or hardly ever discussed studies at home, the average scale score in Connecticut, Florida, and New Jersey was 20 ($p = 0.0004$), 23 ($p = 0.0000$), and 20 ($p = 0.0038$) points higher than the average scale score in Arkansas. Also, African American males who discussed studies every few weeks in the states of Florida and New Jersey had average scale scores that were 14 ($p = 0.0014$) and 19 ($p = 0.0004$) points higher than males who discussed studies every few weeks in the state of Arkansas.

Research Question 2

Regarding research question 2 (Are differences between students' mathematics average scale score impacted by personal interest), we examined differences in average scale score based on students' gender and response to whether they liked math, which is self-reported. We also examined differences in average scale score based on state of residence and response to whether they liked math. Lubienski et al. (2004) found no significant differences between the affective dispositions of African American students. However, we found the following with regard to personal interest, which was under the umbrella of affective dispositions within the NAEP variables. The most significant differences occurred with African American male students who agreed to the statement, "I like math." African American male students in four states (Connecticut, Florida, Illinois, and New Jersey) all had average scale scores significantly higher than African American male students in the state of Arkansas. Specifically, the scale scores of African American males in Connecticut, Florida, Illinois, and New Jersey were 19 ($p = 0.0002$), 19 ($p = 0.0000$), 13 ($p = 0.0134$), and 20 ($p = 0.0002$) points higher, respectively, than African American males in Arkansas.

Discussion

Based on our analysis, we identified several significant differences. First, African American male students who discussed studies 2–3 times a week scored higher than African American female students who discussed studies every day. Second, for African American male students who never or hardly ever discussed studies at home, there were higher scores in Connecticut, Florida, and New Jersey than Arkansas. Third, for African American males who discussed studies every few weeks, scores were higher in Florida and New Jersey than Arkansas. Finally, overall, the scale scores of African American males in Connecticut, Florida, Illinois, and New Jersey was higher than African American males in Arkansas.

Although the results of this study did not yield more noteworthy findings, we still believe that the variables used for this study are meaningful; however, NAEP may not be the best resource for exploring those factors. Nevertheless, from our results, we raise the following questions. What factors allow African American boys, who discuss studies less, to score higher than African American females who discuss studies every day? What is the nature of those discussions for both groups? What factors influence the mathematics achievement of African American students in the state of Arkansas? What educational practices and policies have been implemented to address the 79 % of African American males and 72 % of African American females who score below basic in that state? How can the administrators of NAEP generate greater state participation in 12th grade and from states with greater African American populations? Is there adequate diversity in the structure of the educators and "interested citizens" who determine what knowledge students should know? If not, is this a reason why more states do not participate at the 12th grade level?

According to a report released by the National Center for Education Statistics in 2008, trends in the NAEP data suggest that African American students have made gains in academic achievement. While that should encourage both African American students and parents, there is still cause for concern. One reason is that given the small number of states that participated at the 12th grade and the lack of a nationally representative sample of African American students, one must be very careful about interpreting findings that discuss African American achievement gaps based on this assessment. A second source of concern is the level of performance by African American students who do participate in NAEP. Even when these students feel they are learning, understand what the teacher asks, like math, and plan to attend college, they are still only performing at levels that are below basic or just above basic. Although NAEP data provides a glimpse into achievement, it does not provide explanations for disparities in performance among African American students, which is a complex problem requiring comprehensive solutions.

Consequently, we will discuss three areas known to impact African American student performance including

parental support at home; misalignment between students' educational aspirations and academic achievement and student interest. Parental support at home is necessary in order to positively influence educational achievement in mathematics. In studies examining African American students' success in mathematics, strong parental support was considered vital (Berry et al. 2011; Hrabowski et al. 1998; Martin 2000; Moody 2000; Noble 2011).

In reference to parental support for example, the Meyerhoff Scholars Program (Hrabowski et al. 1998), offers several recommendations for parenting and educating, particularly African American boys, for success in math and science. First, as early as kindergarten, parents must help their children get ahead in school via extensive exposure to educational materials and toys. In addition, the authors encourage direct instruction of basic skills and giving students work at least one grade level above their level of skill. Second, when early aptitude is detected, parents should provide access to special programs that encourage math and science. Third, parents must select an appropriate school setting for their child. Last, parents must also serve as advocates for their children because the needs of African American children are often misdiagnosed, which can result in students being inappropriately placed in classes that take them off a college-preparatory track.

Some might argue that African American parents' ability to assist their children at home is hindered by their feelings of marginalization within schools (Noguera 2003). In fact, he argues that African American parents may feel disadvantaged and marginalized within the school setting and this is evidenced by the underrepresentation of African American and Latino parents who participate in school activities. Literature states that school environments can be insensitive or hostile (Trotman 2001) due to certain barriers, such as language and culture (Aronson 1996); consequently, African American parents' participation within schools is adversely affected (Trotman 2001). In response, Noguera (2003) calls for organization among Black parents to support the education of their children. Some Black parents are answering this call as evidenced by the efforts of parents who enroll their children in learning-focused playgroups and kindergarten-readiness programs (Latour 2012) and parents who collaborate with community-based organizations to assist their schools in monitoring Black students' academic progress as well as active involvement with the school district's reform implementation (Martinez-Cosio 2010).

The second point concerns the misalignment between students' educational aspirations and their academic achievement. From additional analyses, students who planned to attend a 4-year college or who planned to attend graduate school were only at a basic level of achievement. Because of this, a significant threat is posed to those who plan to enter a college or university (Newton 2010). We contend that students must be proficient, at least, to have some modicum of success in a collegiate level mathematics course without requiring remediation. This does not suggest that those deficits cannot be overcome; however, African American students will remain underrepresented in the STEM fields if those challenges are not thoroughly and expeditiously addressed.

Several measures have been used to identify college ready students and include: (1) ability to meet the minimum entrance requirements for a 4-year college with some admission criteria, achievement test scores, grade point average, and a student's access to the information, resources, and skills that will facilitate their navigation of the college admission process (Roderick et al. 2009), (2) access to a challenging curriculum, beginning in middle school (Frome and Dunham 2002; Wimberly and Noeth 2005), and (3) SAT benchmark scores (Kobrin 2007). Absence of remediation appears to be a critical component in Conley's (2007) definition of college readiness; however, one subject that causes many students to be apprehensive (Bandura 1997), requires the most assistance for a great number of students (Parsad et al. 2003), and that heartily challenges a concept of college readiness is mathematics, where remediation is disproportionately higher for African American and Latino students (Adelman 2004).

Two reasons that have been offered to explain why African American students, particularly, are not prepared for college mathematics are their course taking patterns and access to advanced mathematics courses in previous years (Catsambis 1994; Hrabowski et al. 1998; Lubienski 2002; Lubienski et al. 2004). The number of courses taken in mathematics is one of the most powerful predictors of school mathematics achievement in large scale data (Tate and Rousseau 2002; Berry 2008) and also attributes to lower rates of minority students matriculating through college (Riegle-Crumb and Grodsky 2010). African American students are underrepresented in advanced mathematics courses leading to an overrepresentation in lower-level mathematics courses (Ladson-Billings 1997; Tate and Rousseau 2002). Thompson and Lewis (2005) found that increased exposure to content and teaching styles of advanced mathematics courses were beneficial preparation for long-term college success. Students, who take Algebra I before ninth grade, are more likely to gain access to higher level mathematics courses (Lubienski et al. 2004). Enrollment in mathematics courses beyond Algebra II substantially increases the likelihood that a student will attend a college or university (Riegle-Crumb and Grodsky 2010). Over the past few decades, there has been an increase in the number of African American students in advanced placement courses but enrollment in these courses has not translated to an increase in

mathematics achievement as indicated by NAEP (Riegle-Crumb and Grodsky 2010). Scholars (Hrabowski et al. 1998; Hrabowski III and Pearson Jr. 1993) have argued that it is essential for college and mathematics preparation to begin early; however, African American students are filtered out of this pipeline as early as kindergarten and continually filtered out throughout high school (Kao and Thompson 2003; Oakes 1990; Riegle-Crumb 2006). Consequently, Rose and Betts (2001) concluded that by the end of 12th grade, only about 25 % of African American students are prepared to engage college-level mathematics.

In this regard, it is the responsibility of African American parents to actively engage in developing their children's self-efficacy and self-appraisal skills (Bandura 1986). There is a positive correlation between a student's self-efficacy and educational aspirations (Jonson-Reid et al. 2005; Kerpelman et al. 2008; Saunders et al. 2004). It has also been shown that the self-perceptions of African American students can influence academic intentions and performance (Saunders et al. 2004). These findings support a student's thoughts and expectations for upcoming events, referred to as future orientation (Nurmi 1991, 2005). Future orientation, which is associated with future education orientation, is most important during adolescent development (Nurmi 1991, 2005); moreover, internal beliefs significantly influence adolescents' orientation (Nurmi 1991).

Finally, further examination is needed to understand the factors that affect student interest, which is an area that future research should consider giving more attention. We believe that for African American students interest may play a more significant role in their mathematics performance. Ladson-Billings (1997) has suggested that many African American children do not embrace mathematics, devalue it as a necessary skill, and deem it unattainable or undesirable (Ladson-Billings 1997, p. 699). Some consider mathematics insignificant and meaningless to their lives (Powell 1990). Personal and professional experiences in the classroom have confirmed that for some African American students, even after testing into advanced mathematics courses, they may still choose to abstain from these more rigorous classes because they doubt their abilities or believe that prior training has not adequately prepared them for advanced work. While this perspective may not account for all of the underachievement in mathematics, the fact remains that African American students are not performing at an adequate level in mathematics.

Examining how African American student interest in mathematics develops over time may provide some insight on their learning and performance within that discipline. In addition to studying African American student interest, future research should also examine the interest of the students' parents, whose own interests could significantly impact their children's interest. For example, research illustrates that students who show interest in science often have parents in the sciences (Margolis and Fisher 2002; Sonnert 1995). However, if a student does not have parental support, then their interest could still be developed if exposed to an instructor and instructional practices that can identify and target the phase of development for that student's interest (Renninger 2009).

Because a child's initial learning experiences occur at home, parents are the first line of defense for generating interest, which can be facilitated through meaningful discourse at home. It is imperative that parents consider and monitor the behavioral, personal, and environmental factors that affect their children because these components can influence achievement (Bandura 1977). Moses and Cobb (2001) have argued that parents will labor with their children over reading and writing but not mathematics. These parental behaviors send strong messages about their interest in mathematics. Children take these cues and use them to inform their own attitudes and levels of interest (Martin 2000).

In addition to the small sample size, one of the limitations of this study involves the self-reported data for frequency of discussions, concerning studies, at home. The item indicates discussions with a family member; however, the item does not identify which family member or the nature of the conversation. If this item is kept in the NAEP assessment, then it may be helpful to ask participants to identify which family member they discuss their studies with the most. Additionally, the frequency of discussions with mothers versus fathers could be assessed. This information could prove beneficial since it has been suggested that African American boys and girls are socialized differently in terms of academics (Jeynes 2005).

In conclusion, educating African American students, specifically in mathematics, necessitates a more holistic approach that genuinely attends to the challenges involved. Home environment and personal interest are only a part of the equation but are integral to bolstering educational opportunities among these students. The focus must shift away from achievement gaps to the realization of these students' academic potential, where below basic is not the standard.

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