Maximizing Opportunities to Enroll in Advanced High School Science Courses: Examining the Scientific Dispositions of Black Girls

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ABSTRACT: Diversifying the STEM workforce is a national concern. To address this concern, researchers, policymakers, and educators are working to increase STEM career interest and achievement in a more diverse population of learners. Black girls and young women represent a unique population of STEM learners that remain relatively untapped and largely under researched in current STEM education scholarship. Therefore, this study focuses on the relationship between the science dispositions of Black girls and advanced science course enrollment. The present study utilized a sample of Black female students (N = 1,810) that participated in the High School Longitudinal Study of 2009/2012 (HSLS:09/12). To examine whether science dispositions are predictive of general enrollment in advanced science courses a canonical correlation analysis (CCA) was performed. The observed relationship between science dispositions and participation in advanced science of r = .389 and explains 15.13% of the variance. The majority of the predictive information for the science disposition construct was observed in science identity. Therefore, the development of science identity in Black girls should be the focus of educators and parents seeking to increase Black girls' participation in advanced science courses. Implications are provided for parents and educational stakeholders of Black girls.

Keywords: Black girls, Advanced Placement, International Baccalaureate, STEM, science disposition, gifted under-representation

Diversifying the STEM workforce is a national concern. Many U.S. jobs in STEM fields remain unfilled due to a lack of quality workers (Atkinson, 2013). Demographic trends and STEM participation rates suggest that, rather than relying exclusively on students who have already demonstrated high achievement to pursue STEM education, the U.S. needs to inspire, engage, educate, and employ as broad a population as possible in STEM-related professions (Ranis, Means, Confrey, House, & Bhanot, 2008). To address this concern, researchers, policymakers, and educators are working to increase STEM career interest and achievement in a more diverse population of learners. Students in urban schools have the potential to help diversify the STEM workforce. Unfortunately, many of these students lack access to the resources and support necessary to matriculate through the STEM pipeline. Research in urban education provides evidence to support this assertion as it related to Black students in general and Black male students specifically (McGee, 2013; Rogers-Chapman, 2014). However, Black girls and young women represent a dually marginalized population of STEM learners that remains relatively untapped and largely under-researched in current STEM education scholarship.

Black girls possess many characteristics that can support their persistence in STEM courses and professions. The odds of being interested in a STEM career are almost three times higher for males than for females (Sadler, Sonnert, Hazari, & Tai, 2012). However, many Black girls have a strong affinity for STEM professions that is often not affirmed or, in the extreme case, discouraged. According to Hill, Corbett, and Rose (2010), despite early interest, Black women face unique obstacles in STEM, including teacher bias and poor institutional support for pursuing STEM. This is important given the historical under-representation of women in general and women of color in particular in STEM.

Approximately 75% of American scientists and engineers are White, and only 10% of STEM professionals are women of color (Feller, 2012). These positive STEM attitudes can be leveraged to redress these trends to increase Black female STEM participation. Additionally, non-traditional gender achievement socialization patterns have propelled Black girls and young women to consistently outperform their male counterparts in most STEM related academic tasks. Black girls outperform Black boys in every measured academic domain (Varner & Mandara, 2014). This phenomenon is often attributed to the gender socialization of Black girls compared to their non-Black female peers.

Empirical evidence suggests that parents raise their daughters and sons differently (Bornstein et al., 2008). However researchers suggest that Black mothers foster competence and self-reliance in their daughters, thus they are firmer with their daughters than their sons (Collins, 1987; Staples & Johnson, 1993). These gender socialization patterns translate into the higher academic performance of Black girls compared to Black boys. For example, Black student achievement on tests is directly related to differences in parent socialization based on gender (Wood, Kaplan, & Mcloyd, 2007)). Subsequently, 59% of Black girls graduate from high school compared to only 48% of Black boys (Lewin, 2006). Given these unique intrapersonal and academic characteristics observed in Black female students, it is important to assess how these constructs are related within the STEM education domain.

Purpose

The objective of this study was to examine the relationship between enrollment in advanced high school science courses (Advanced Placement (AP) and International Baccalaureate (IB)) and science dispositions (e.g., identity, utility, self-efficacy, and interest) in a representative sample of Black female high school students. Often students of color (Black and Hispanic) are not afforded opportunities to enroll in such classes compared to White and Asian students. National Science Foundation data shows that Black women and girls are under-represented, given that they comprise only 10.4% of the female graduates in STEM fields (National Girls Collaborative Project, 2013). This study is of importance because the scientific dispositions of Black girls are sparsely examined in the literature. Black girls are a uniquely diverse and academically resilient population of learners. Therefore, highlighting the usefulness of disposition data to inform the recruitment and retention of Black girls and women as potential STEM learners and professionals is paramount.

Conceptual Framework

Science dispositions are integrally related to enrollment and achievement in advanced science coursework and subsequent STEM achievement and careers. Wang (2013) posited that readiness in mathematics and science, in particular, is correlated with students' decision to choose a STEM major. Students who participate in rigorous mathematics and science courses in high school are more likely to both pursue and complete degrees in STEM fields (Schneider, Judy, & Mazuca, 2012). This trend is true for Black students; however, many attend schools that do not offer advanced mathematics and science courses (e.g., AP classes) pivotal to college STEM success (Tyson, Lee, Borman, & Hanson, 2007).

In addition to being academically prepared for STEM fields, Black girls must also possess positive dispositions toward STEM content. Preparation and dispositions are integral to STEM success. Prior research suggests that STEM dispositions vary by race and gender, with Black women having more positive attitudes toward STEM than other female racial groups (Hanson, 2009). This is important because, while it demonstrates Black girls' positive dispositions toward STEM, external forces may taint their interest. Students who face multiple levels of minority status, particularly Black women, contend with additional challenges of dual stereotypes and power inequities. This creates 'multiple jeopardy' for Black girls whose gender and race may influence how they are perceived within STEM classes. According to Francis (2012), teachers perceived Black girls as disruptive and were less likely to recommend them for honors courses (Campbell, 2012). Black females are also under-referred for gifted education and AP classes (Ford, 2013); under-referral exists even when Black students have the same academic profile as White students (e.g., Grissom & Redding, 2016).

Although the first step in creating opportunity for Black girls is making advanced classes available, it is not sufficient for diversity or inclusion in STEM. Educators must understand that decontextualized learning does not foster a strong science disposition among students, but introducing high school students to a strong sense of the utility does (George, 2003). Science utility refers to an understanding of the 'usefulness' of science; students must see a purpose and relevance, personally and professionally. Additionally, prior research shows positive outcomes when students are presented with rigorous curriculum, positive academic engagements and hands-on science learning experiences on 'what it is to do science' (Ero-Tolliver, 2013). These activities reaffirm student's knowledge, increase their persistence in STEM and strengthens their science identity, the students' belief that they are a 'science person' (Hunter, Laursen, & Seymour, 2006). Differences in STEM interest vary across race and gender. Trends in gender differences in STEM interest and achievement suggest that males are more interested and proficient in STEM despite similar gender enrollment trends (Choi & Chang, 2009). However, racial differences exist -- 62% of Black students express disinterest in STEM fields (Business-Higher Education Forum, 2011). Some students did not enroll in advanced classes because they were unaware of the opportunities or experienced lack of confidence in their capabilities (Darity et al., 2001; Young, Ortiz, & Young, 2017; Young & Young, 2015; Young & Young, 2016). Therefore, all educators should value the unique science utility, interests, identity differences, and cultural capital of Black girls as they expose them to what it means to engage in STEM.

The relationship between science dispositions and science course enrollment has important implications for the sustained participation of Black girls in STEM. Pre-college experiences, previous coursework in high school, race, and gender are all crucial to a student's science disposition and career decisions (DeMarie & Aloise-Young, 2003; Gordon & Steele, 2003; Larke, Webb-Hasan, Jimarez, & Li, 2014; Simpson, 2001). Thus, it is imperative that educators place special attention and consideration on the relationship between Black girls' science dispositions and science course enrollment. Although gender parity in high school math and science enrollment is more common than ever, significant enrollment disparities across different races and socio-economic levels persist. Therefore, our study focuses on the relationship between the science dispositions of Black girls and advanced science course enrollment.

Methods

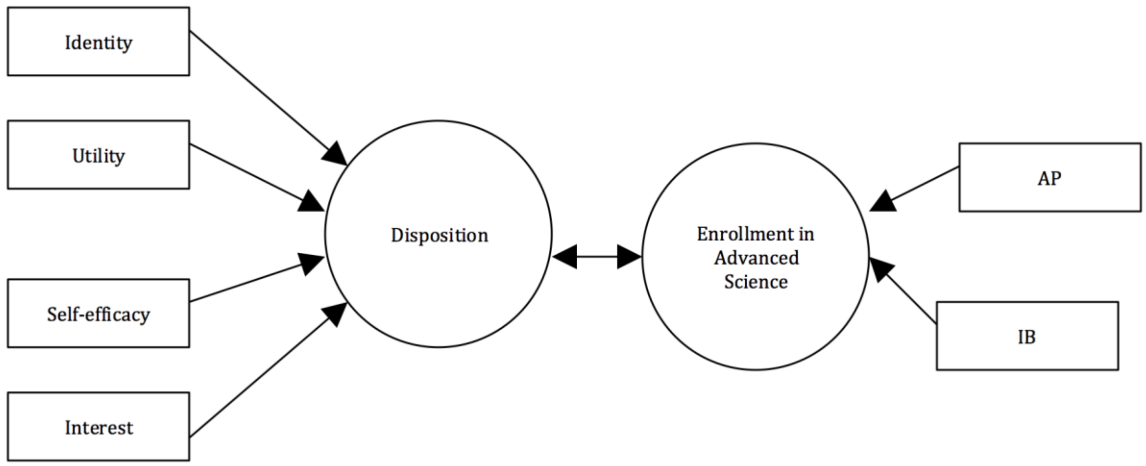
The present study utilized a sample of Black female students ($N = 1{,}810$) that participated in the High School Longitudinal Study of 2009/2012 (HSLS:09/12). Students were randomly selected from a pool of over 21,000 students from 944 public, charter, and private schools in the United States. The base year data collection included online surveys administered to students, parents, science teachers, and administrators. In subsequent follow-up administrations, similar online surveys were administered to parents and students. These variables represent the independent and dependent variables examined in the present study.

To assess the construct validity of the HSLS:09/12, researchers conducted a principle components factor analysis (Ingles et al., 2014). In the present study, we examined the following scales: (a) Science Efficacy Scale (X1SCIEFF); (b) Science Interest Scale (X1SCIINT)(c) Science Identity Scale (X1SCIID); and (d) Science Utility Scale (X1SCIUTI). The reliability of these scales as measured by Cronbach's alpha ranged from .69 to .89. The aforementioned scales were standardized to a mean of 0 and standard deviation of 1. To assess the relationship between this variable set and participation in advanced science, we utilized two outcome variables (1) Enrollment in AP science and (2) International Baccalaureate (IB) science courses. Enrollment in AP science (S1APS) is a dichotomous variable that asks students if they plan to enroll in AP Science. Responses were statistically constrained to "yes" or "no." Similarly, enrollment in IB was dichotomously scaled using this question stem.

Analysis

To study the relationship between Black girls' science dispositions and enrollment in specific advanced high school science courses, the correlation matrix and partial correlations between all predictor and dependent variables were obtained. Then, to examine whether science dispositions are predictive of general enrollment in advanced science courses a canonical correlation analysis (CCA) was performed. CCA was chosen because the purpose of the analysis was to assess the ability of the set of science disposition predictor variables to predict a separate set of variables representing general enrollment in advanced high school science. Because the objective was to assess the relationship between variable sets, CCA was the most appropriate analytic technique. Furthermore, the multivariate nature of CCA limits the probability of committing a Type I error. In theory, we could conduct two separate regression analyses. This would increase the "test wise" error rate, thus it was avoided. Figure 1 presents a pictorial representation of the relationship between the two variable sets modeled in this study. Data were analyzed in IBM SPSS Statistics 20.0 to examine the independent overall relationships present in this dataset.

Figure 1. Illustration of the first function in Canonical Correlation Analysis



Results

Descriptive statistics for each of the science disposition scales and advanced science course enrollment items are presented in Table 1. Scores were largest for utility, followed by self-efficacy, interest, and identity. Students' reported intentions suggest that approximately 22% and 8% of Black girls planned to enroll in AP or IB science, respectively.

Table 1: Descriptive Statistics for Predictor and Criterion Variables

	M(*SD*)
Science Identity	-.109 (.991)
Science Utility	.133(.933)
Science Self-efficacy	.027(.812)
Science Interest	-.045(.886)

Table 2 presents the correlation matrix between all variables. All variables were statistically significantly correlated. As presented in Table 2, observed correlations range from .15 to .48. Science identity had the largest correlation with enrollment in both AP and IB science, although the relationship between identity and IB enrollment was weaker.

Table 2: Correlation Matrix

	Identity	Utility	Self-efficacy	Interest
Utility	0.243			
Self-efficacy	0.385	0.384		
Interest	0.326	0.349	0.476	
AP	0.327	0.173	0.246	0.276
IB	0.164	0.136	0.160	0.149

All constructs were statistically significantly correlated at $p < .05$.

A CCA was conducted using four disposition variables as predictors of two measures of high school enrollment in advanced science courses to evaluate the multivariate shared relationship between the two sets of variables. The analysis yielded two functions with canonical correlations of .389 and .060 for each function. Collectively, the full model across all functions was statistically significant using the Wilks's $\lambda = .849$ criterion, $F(1,802) = 23.85$, $p < .001$. As observed in Table 3, the predictor that has the greatest weight in the CCA is science identity followed by science interest. Coefficients with the same sign indicate a positive relationship, while an opposite sign represents an inverse relationship. All of the predictors were positively related to the outcome variables in the model.

Table 3: Canonical correlation among disposition and high school achievement variable sets

		Weights	Canonical Correlation
Disposition Variables	Identity	-0.627	0.389*
	Utility	-0.114	
	Self-efficacy	-0.186	
	Interest	-0.394	
Enrollment Variables	AP	-.917	
	IB	-.175	

* indicates a statistically significant correlation at p <.05

Discussion

The canonical correlation between science dispositions and participation in advanced science must be interpreted in context. Contextually, this is a relationship between a student's attitude and a behavior. According to Bosco, Aguinis, Singh, Field, and Pierce (2015), an observed correlation of $r = .255$ (ES = .065 or 6.5% of the variance) represents a large effect size in this context. Thus, the observed relationship between science disposition**s** and participation in advanced science of $r = .389$ explains 15.13% of the variance and is substantial when placed in context. Additionally, the data shows that science identity had the highest correlation with AP and IB sciences, and that science identity, followed by science interest and self-efficacy, were positive predictors of enrollment in advanced high school science courses for Black girls. Self-efficacy, interest, and utility were substantially less influential constructs in the canonical correlation. This suggests that the majority of the predictive information for the science disposition construct was observed in science identity. Therefore, the development of science identity in Black girls should be the focus of educators and parents seeking to increase Black girls' participation in advanced science courses.

Limitations

This study presents correlational research results that model the relationship between scientific dispositions and Black female student participation in advanced science courses. One limitation of correlational research is the inability to make causal inferences. Therefore, this study does not indicate that positive science dispositions cause Black girls to enroll in advanced science courses. However, this study does indicate that positive science dispositions predict participation in advanced science courses for Black female students. Therefore, it is important to acknowledge that correlation does not indicate causation, but rather the strength of the predictive relationship between two variables. Also, although this study shows a correlation between advanced science and science disposition for Black girls, it does not directly provide the narratives from self-reflection of Black girls. More studies need to be conducted to document Black girls' perception of whether they 'feel like a scientist' or see themselves as potential scientists after 'doing science' in the classroom or after passing advanced science courses.

Conclusion

This study is significant because, in order to increase equal opportunities in advanced science participation, it is important to understand how the science dispositions of Black girls predict advanced science course enrollment. This study also presents foundational understandings of the scientific dispositions of Black girls that can inform further critical examination of access, equity, and achievement related to race and gender. Pre-existing studies show the rate of enrollment in most STEM classes is similar with respect to gender, but there is a stark difference when one isolates the data into gender *and* race. This illuminates the fact that studying advanced science course enrollment based on gender alone is not sufficient to diversity the pool of qualified applicants for STEM fields, but other factors such as race must be considered.

It is critical that families and educators begin early to prime the STEM pipeline for Black females, which includes increasing access to gifted programs and AP classes. In elementary school and all grade levels, Black girls need exposure to science, with attention to mentors and role models who share their race and gender (Young, Feille, & Young, 2017; Young, Young, & Paufler, 2017). That is, these students must be exposed to Black females in STEM as one strategy to increase or reinforce their interest, self-efficacy, and identity, along with the utility value of science. In addition to STEM professional exposure, immediate classroom actions should include teachers and counselors serving as advocates for Black girls by consciously amending classroom activities that help increase students' science identity and utility, such as advanced, project-based, hands-on science activities that include active learning in the classrooms. Curriculum should be relevant to Black girls, providing real world and culturally relevant literature and lesson plans (Ford, 2010). In conclusion, the results suggest that examinations of race and gender are critical to priming the diversification of the STEM pipeline.

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