STEM Education: The Answer to Improving Black Students’ Academic Achievement in Mathematics

Shirley Marie Headen
High Point University
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Introduction

“The colour of the skin is in no way connected with strength of the mind or intellectual powers.” —Benjamin Banneker

The achievement gap still persists in America’s public school system. More specifically, Black students are scoring significantly lower than white students on mathematics tests. Based on the National Assessment of Educational Progress (NAEP), 91% of Black students are not proficient in mathematics by the time they reach eighth grade compared to the 63% of White students and 53% of Asian American students (Flores, 2007). Since the institution of standardized testing in public schools, there has been evidence of a significant disparity of test scores between the White and Black student population.

My personal interest in the educational issue of the achievement gap stems from my analytical nature of wanting to understand the cause of and solve this persistent phenomenon called the achievement gap. As an educator, I value the ideal that education is the key to success. Therefore, if the Black student population continues to be low-performing compared to their White counterparts, success seems to be at a further grasp for Black people as a whole.

In the course of my research, my innate curiosity about the achievement gap is shared with many researchers. Research begins to tackle the achievement gap by first explaining the causes of the achievement gap. By only looking at the statistics, one can be led to form an uninformed explanation that people of African descent may be born less intelligent than people with more European ancestry. This explanation of Black students’ academic achievement has been disproved by multiple research studies that have been articulated in Lisa Delpit’s book,
“Multiplication is for White People: Raising Expectations for Other People’s Children” (2012). Based upon the studies done in the 1950s, 1960s, and 2006, Black babies show slightly higher levels of cognitive skills compared to White babies. There is no achievement gap at birth, so the current achievement gap in the school systems cannot be explained by innate capability. If biological reasoning was the cause of students’ success in school, then research should show that, if anything, there should be an achievement gap of high-performing Black students compared to low-performing White students. Therefore, research has expanded its examinations to find plausible causes of the achievement gap. Explanations range from extreme explanations such as Ogbu’s oppositional culture theory (Downey, 2008) to re-identifying the issue as an “opportunity gap” between underrepresented minorities and White and Asian American students (Flores, 2007) (Xie & Farge & Shauman, 2015).

After identifying causes of the achievement gap, researchers have what they need to cite efficient strategies to closing the achievement gap in mathematics. Balfanz and Byrnes (2006) share Mueller’s belief (2005) that an entire school’s environmental framework needs to change in order to close the achievement gap. Multiple literature also suggests strategies at a classroom level. For instance, the math teacher’s pedagogy in the classroom affects the achievement of minority students’ achievement. Common explored strategies to diminish the disparities in mathematics education are more qualified and experienced teachers, high expectations, and relevant, real-world problems for Black students.

There is even more research on effective strategies to close the achievement gap within the STEM field. Anderson and Kim (2006) discuss the issue of low numbers of underrepresented minorities in STEM (science, technology, engineering, and mathematics) professions. Black students seem to possess a lower level of persistence in undergraduate STEM degree programs
compared to Asian American and White students. The Institute for Broadening Participation (2016) suggest that students’ exposure to more minority role models in the STEM field and culturally relevant pedagogy in science and mathematics instruction are solutions to closing the achievement gap.

With all of this literature on the importance of closing the achievement gap, researched causes of the achievement gap (or opportunity gap), and efficient strategies to close the achievement gap, there is still an existence of an achievement gap between White students and under-represented minorities. From the suggested strategies in this collected literature to close the achievement gap and improve academic achievement among underrepresented minorities (Black students in particular), there seems to be no connection on how STEM education incorporates most of the researched strategies needed to close the achievement gap. STEM education is based on guiding principles, practices, and instructional pedagogy that are identical to the efficient strategies mentioned in this literature. There is plenty research on the lack of underrepresented minorities in STEM professions and how to increase the number of URMs in STEM fields. However, there is a lack of literature that focuses on the effects of STEM education on Black students’ achievement in mathematics. Throughout this literature review, I plan to analyze the causes of the achievement gap, categorize the collective strategies needed to close the achievement gap, and compare the basis of STEM education to the researched solutions to closing the disparity of achievement in mathematics. By synthesizing the research literature, I accomplish what the literature does not and make the connection that STEM education in the classroom can be the main solution to close the achievement gap between Black students and White students. Thus leading to inquiry about the effects of STEM education on Black students in a mathematics classroom.
Causes of the Achievement Gap

“If I had an hour to solve a problem I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions.” –Albert Einstein

Oppositional Culture Theory

The oppositional culture theory is a radical explanation to Black students’ low achievement in school. Originated by Nigerian-American John Ogbu, the theory states that the black culture is the primary culprit to its own underachievement in school. Downey (2008) further explores Ogbu’s theory by distinguishing between the perspectives of education from voluntary minorities and involuntary minorities. Voluntary minority groups who have migrated to America on their own free will value education as important to success. Involuntary minority groups who were historically brought to America against their own free will view education as a short-term obstacle standing in the way to actual success. According to this oppositional culture theory, viewing education as important is shamed in the black community. Therefore, having a good work ethic and performing well in school is perceived negatively with name calling such as “acting white.” Discussion in Balfanz and Byrnes’s (2006) research indicates factors such as better classroom attendance, appropriate behavior, and better effort in high-poverty middle schools in order to close the mathematics achievement gap. These factors mentioned by Balfanz and Byrnes are the same factors that Downey states will alienate black students from their black peers as “selling out” or “acting white.” As a result, black students purposely perform poorly to maintain acceptance within the Black culture.

Proof of the oppositional culture theory being the cause of Black student’s low academic achievement can be disproved by the research of Downey. Downey mentions that the data collected contradicts the oppositional culture explanation. The majority of Black students from
the study actually value education. Downey contributes this to not being able to trust Black students’ responses, which could be a racial bias of Downey to the Black minority group as a whole. Similar to Downey’s research, Balfanz and Byrnes credit minority students as being the reason for their own demise. However, the factors of behavior in class and trying hard to learn are both subjective to teachers, who may be heavily influenced by biases of “traditional style” approaches and racial discrimination. What one believes to be a lack of effort on a students’ part may be viewed by another person as disengagement to the “traditional style” teaching approach. The research agrees students do need to take ownership for their learning, but there is a possibility that there is an even deeper explanation for Black students’ low performance in schools.

Opportunity Gap

Multiple research articles agree that Black students do not receive the same amount of educational opportunities as White students. From a socioeconomic perspective, there are higher percentages of Black children than White children living in low-income families. According to the National Center for Children in Poverty (2014), Blacks have the highest percentage of children living in low-income families. Sixty-five percent of Black children live in low-income families while thirty-one percent of white children live in low-income families. Since school districts are partitioned by socioeconomic statuses of neighborhoods, it is more likely for high-poverty schools to be composed of underrepresented minorities (Hispanics, American Indians, and Blacks).

High-poverty schools lack the educational opportunities received by students in a low-poverty school. Flores (2007) identifies the low performance of minority students as an opportunity gap instead of an achievement gap. Schools that have lower percentages of low-
income families receive teachers with more teaching experience, better prepared teachers, rigorous curriculum (i.e. more Advanced Placement courses), and smaller class sizes. Conversely, high-poverty schools usually have teachers with little experience, underprepared teachers, little to no rigorous curriculum, and overcrowded classes (Mueller, 2005). Xie, Fange, and Shauman (2015) agree that underrepresented minorities lack the opportunities to develop deep connections with science, resulting in the disparity in test scores.

Efficient Strategies to Close the Achievement Gap

“Except during outbreaks of vicious bigotry, it is difficult to persuade white America that the alienation of Black America is actual and ongoing, afflicting each generation through policy, custom, quack science, and if nothing else, the Look.” –Theresa Perry

School/Classroom Level: Pedagogy is Key

Ladson-Billings (1997), Brown (2007), Congressional Research Service (2012), The Institute for Broadening Participation (2014), and Mueller’s Wilder Research (2005) have the common theme of the teachers’ pedagogy being a major factor in Black students’ academic achievement. A teacher’s mindset that all students are competent and capable of achieving high expectations resulted in Ladson-Billings study of a sixth grade mathematics teacher’s poor-performing Black students improving to a high-performing level. Brown’s dissertation in 2007 supports Ladson-Billings account by emphasizing a culture of high expectations in order to increase minority students’ achievement. The Congressional Research Service (2012) identified a culturally relevant pedagogy and early exposure to STEM fields as positive influences for the success of minority students in K-12 grade level classrooms. The Institute for Broadening Participation (2014), Congressional Research Service (2012), and Ladson-Billings (1997) specifically name a culturally relevant pedagogy as an efficient strategy for closing the achievement gap. Therefore, basing mathematics instruction on the issues minority cultures face
in the real-world creates a connection to the learning for minority students. The Institute for Broadening Participation takes it a step further by mentioning the importance of exposure to more minority role models in STEM fields. Students being able to see someone from their same ethnicity/race achieving in the mathematics field will promote self-efficacy of the Black students because high academic achievement in mathematics will begin to seem attainable. As a result, Black students perform at higher levels due to the relevancy of the mathematics lesson. It is no longer learning how to divide in order to pass a test so they can get through the math class. Culturally relevant pedagogy makes it an intrinsic motivation to learn how to divide by solving a problem that will affect their quality of life.

Mueller (2005) states how challenging, rigorous curriculum is a key characteristic of a school system in order to close the achievement gap. Having high expectations within the curriculum exposes minority students to higher level thinking skills needed to be successful academically. When teachers approach Black students with the “pedagogy of poverty”, meaning that the teacher lowers expectations for the Black students, they are doing a disservice to the students which perpetuates the achievement gap in America.

Other effective classroom strategies to improve Black students’ achievement arise from Flores’s article (2007). Unlike the other articles, Flores focuses more in-depth on actual mathematical practices needed to contradict traditional style teaching in order to improve Black students’ math success. The strategies include helping students develop relational understanding of concepts, number sense, and a safe classroom environment where students’ solutions are heard instead of mocked. With these strategies to close the achievement gap in mathematics, the teacher is responsible for the culturally relevant pedagogy that has students use mathematics as a tool to examine social issues dealing with race, ethnicity, gender, and social class.
District/School Level

The above-mentioned classroom and school-level strategies for closing the achievement gap can also be incorporated more on a district level as well. In addition to enforced culturally relevant pedagogies in the district school system, a whole-school reform (WSR) model has been proven by Balfanz and Byrnes’s research on three Philadelphia high-poverty middle schools to close the mathematics achievement gap (2006). When WSR models were incorporated in each of the three schools, there were significant gains in academic achievement in math scores compared to the other twenty-three schools in the Philadelphia school district. Therefore, a whole school reform where everyone is on one accord in a harmonious learning environment results in a major contribution needed to close the achievement gap in mathematics.

Efficient STEM Strategies—Are They Sounding Familiar?

“Education is our passport to the future, for tomorrow belongs only to the people who prepare for it today.” –Malcolm X

As this literature review continues with the STEM (science, technology, engineering, and mathematics) guiding principles put forth by Vasquez, Sneider, and Comer (2013) and some STEM instructional models, there will be repetitive strategies mentioned in the previous section about effective strategies that will close the achievement gap. Because of these similarities in strategies, I am synthesizing them by stating STEM education as the answer to closing the achievement gap between Black students and their White peers.

STEM Guiding Principles

There are five guiding principles of Science, Technology, Engineering, and Mathematics education: focus on integration, establish relevance, emphasize 21st century skills, challenge your students, and mix it up.
Integration is an effective teaching approach that is taught to well-prepared teachers through post-secondary education and/or teacher professional development programs. Learning subject disciplines is a 21st century approach to teaching that dismisses the “traditional-style” teaching that only focuses on one subject. The idea behind integrating other subjects within one discipline mirrors the real world. In the real world, we combine multiple disciplines in order to critically think and solve a problem.

Establishing relevance exactly aligns with the achievement gap strategy of incorporating culturally relevant pedagogy in the classroom. This STEM principle explained in Vasquez, Sneider, and Comer’s book (2013) reiterates the Institute for Broadening Participation (2014), Congressional Research Service (2012), and Ladson-Billings’s (1997) research about having a learning environment that focuses on solving problems dealing with race, ethnicity, and social class so students can connect to the learning. Flores’s suggestion (2007) to “enable students to use mathematics as a tool for examining issues related to race, ethnicity, gender, and social class” establishes relevance of mathematics to help individual students, their families, and their community.

Pedagogical frameworks that focus on developing concepts emphasize twenty-first century skills of communication, teamwork, problem solving, critical thinking, and creativity. In Jobrack’s article explaining the 5E instructional model for teachers to use, students go through five stages of learning that promote twenty-first century skills (2013). Within the 5E instructional model, there is a focus on crafting students’ concepts in order for learning to happen. Wells (2016) explains the conceptual/pedagogical framework of integrative STEM education that is titled, “P.I.R.P.O.S.A.L. Model.” Having students go through the PIRPOSAL phases of engagement while finding solutions to engineering-type challenges requires students to do
problem identification, ideation, research, potential solutions, optimization, solution evaluation, alterations, and learned outcomes. Both pedagogical frameworks of PIRPOSAL model and the 5E instructional model present rigorous curriculum to students while simultaneously achieving the fourth STEM guiding principle of challenging the students. Therefore, the incorporation of these pedagogies by teachers in schools with low-performing Black students will increase rigor that will result in their higher academic achievement as mentioned in Mueller’s (2005) and Flores’s (2007) research.

Mixing up how students share their knowledge aligns with Mueller’s key characteristic of closing the achievement gap in grades K-12 by aligning curriculum, standards, and assessments (2005). Teachers and students will benefit from differentiated assessments by increasing engagement among students and creating a better picture of students’ understanding within mathematics.

Conclusion

“The art of teaching is the art of assisting discovery.” –Mark Van Doren

In conclusion, there are reoccurring solutions in the literature to closing the achievement gap in mathematics that are also reoccurring in the literature about the basis of Science, Technology, Engineering, and Mathematics (STEM) education. The literature identifies that there is a huge underrepresentation of the Black population in STEM majors and professions compared to Whites and Asian Americans (Anderson & Kim, 2006). The literature also identifies that culturally relevant pedagogy and higher expectations by the teacher are crucial to closing the achievement gap in mathematics. However, the literature does not make the connection that the strategies mentioned to close the achievement gap in mathematics are addressed by the conceptual instructional frameworks associated with STEM education. The
Diversity in Mathematics Education Center for Learning and Teaching in 2007 concluded that there is a need for looking outside of the field of mathematics education for theoretical perspectives and methodologies that will contribute to improving mathematics teaching and learning. Therefore, I plan to use the STEM instructional approaches (5E learning cycle and/or PIRPOSAL Model) to plan instruction with the STEM guiding principles of integration, culturally relevant real-world application, emphasizing twenty-first century skills, challenging students with higher order thinking performance tasks, and variety in assessments in the forefront of my mind as a sixth grade mathematics teacher.
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