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Promoting Equity: Examining a Model of Success for African American Women in Mathematics

Viveka Borum
Spelman College

A model of success (MoS) is proposed by the researcher for African American women and women in general, who are pursuing degrees in the field of mathematics. The model was developed by examining the historical and present-day experiences of African American women mathematicians. This model describes extrinsic and intrinsic factors that mediate the educational experiences of African American women in mathematics.

Keywords: African American women, mathematics, model of success

Introduction

When considering issues of equity in mathematics, researchers often talk about the need to increase women and underrepresented racial and ethnic groups in science, technology, engineering, and mathematics, i.e., STEM fields (Marra, Rodgers, Shen, & Bogue, 1999; National Science Foundation, 2011; Towns, 2010). For example, there is a dearth in the number of African American women attaining STEM degrees at the collegiate level, despite the fact that a substantial percent of African American women have the intention to major in STEM fields upon matriculation. In 2008, about 32% of first year African American women reported their intentions of majoring in a STEM field (National Science Foundation, 2011); however, this percentage decreases for African American women by the time of graduation. Several reasons have been suggested as to why women and other underrepresented groups shy away from STEM arenas, such as lack of role models or mentors, lack of advising, feelings of isolation, and lack of community (Joseph, 2012; Towns, 2010).

By exploring the experiences of mathematicians who are African American women, a Model of Success (MoS) was developed, specifically, for African American women pursuing their education in mathematics. The MoS organizes various factors that mediate the educational experiences of African American women who sought their doctorate in pure and applied mathematics. This model continues a conversation for educators, researchers, and others invested in increasing the number of African American women and other underrepresented groups with degrees in mathematics.

The MoS provides a structure to understand the following questions:

1. What factors contribute to the success of African American women in mathematics?
2. What factors can be a deterrent or challenge for African American women in mathematics?

Brief Literature Review of Study

As previously mentioned, studies continue to explore the paucity of women and underrepresented racial and ethnic groups in mathematics and other STEM fields. Few studies speak to African American women in mathematics and, for those studies that do, they generally address the lack of African American women represented in the field (Gasman & Perna, 2011; Malcom & Malcom, 2011; Towns, 2010). Some of these studies discuss the ways that various programs and institutions, in particular, historically black colleges and universities (HBCUs), increase and promote degree attainment in STEM fields. The role of HBCUs are important with respect to African Americans earning science and engineering bachelor's degrees although their enrollment has decreased over time (National Science Foundation, 2011). Some of the factors that contribute to African American success at HBCUs in STEM fields relate to social and psychological elements, such as peer support groups, extra-curricular activities and events, positive self-efficacy about their success, and a feeling of belonging (Allen, 1992). Since not all African American women pursuing mathematics attend HBCUs, it is imperative to consider a broad array of factors that lead to the success for African American women regardless of the institutional context.

Some studies suggest that it is beneficial to expose girls and minorities to mathematics in the K–12 grades. Igniting an early interest can create a bridge into the field of mathematics once they enter college. If students, in particular African American and Latino students, are exposed at an early age to research, internships, and other programs in mathematics then they can gain a greater appreciation and a more informed decision about whether they want to pursue a mathematical field (Horwedel, 2006). In addition to research, exposure to female mathematicians in the early grades can be beneficial to both females and males (Wiest, 2009).

Encouragement in the K–12 grades to pursue a mathematics career is also pertinent. Since the types of encouragement can vary, it is suggested to provide students with individualized forms of encouragement. Heilbronner (2009) denotes this form of encouragement as "prescriptive informational feedback" and teachers must first develop a relationship with their students and know their mathematical abilities to provide feedback that will enhance and encourage students to improve when necessary. Using descriptive feedback for encouragement has been cited to help females increase their self-motivation in mathematics (Tucker, 2000).

Two of the factors viewed in the MoS model for deterring African American women from mathematics are involuntary isolation and low expectations in mathematics due to gender and/or race. Involuntary isolation refers to separation experienced by African American women from certain faculty and students in their mathematics courses and communities. The norms and culture of certain mathematics programs and communities were organized in such a way that often hindered the acceptance and participation of African American women and other underrepresented groups in mathematics. This involuntary isolation status can lead to an "outsider within" status (Collins, 1991). The notion here is that mathematicians who are African American women may be permitted into mathematical communities formally, however, depending upon the previous norms established, these African American women mathematicians may feel as if they are not a part of that particular community.

Low expectations due to gender and/ or race in mathematics can be viewed through the lens of Steele's (1997) notion of "stereotype threat." Since mathematics has been historically a white male-dominated field, the "norms" and "standards" that were previously set in place for people studying mathematics have excluded African American women and other minorities. For African American women, it is referred to as a "double bind" (Malcom & Malcom, 2011) and this can often hinder African American women from advancing in mathematics. As Steele (1997) states, "Negative stereotypes [regarding women and African Americans] can be sharply felt and, in several ways, hampers their achievement" (p. 614).

Methodology

The MoS for African American women in mathematics is based on a qualitative study consisting of twelve African American women who have received their doctoral degrees in pure or applied mathematics (Borum, 2010). Semi-structured interviews were conducted lasting from one to two hours. The interview protocol consisted of questions relating to the women's personal, professional, and formative experiences in mathematics, such as: How did you become interested in mathematics? Did you work together in mathematics with other students in elementary, middle, or high school? How did you decide to major in mathematics in college? What was the response of your family, friends, and teachers? How would you define your role models or mentors? The interviews were transcribed and then coded using a qualitative data analysis software program. The coding was conducted in three phases: open, axial, and selective (Strauss, 1987). Through these phases, the similarities, differences, and a cross comparison of

the women's experiences was established. Although some of the women's stories were similar, it was important to appreciate each of these women as individuals, who had incurred various successes, obstacles, and challenges. After interviews were read, transcribed, and coded several times, the MoS was created.

In creating the MoS, a Black feminist thought framework, in conjunction with grounded theory analysis, was used. This framework adheres to three pertinent themes when examining the lives of African American women. The framework is shaped by the experiences of Black women, the framework explores the intersections of the Black women's experiences while retaining the women's own unique stories, and the framework acknowledges the commonalities of the Black women's experiences but also views diversity of the women via class, religion, age, or sexual preference (Howard-Hamilton, 2003). In addition, a historical component was used to look at African American women and women generally in mathematics for developing the MoS. Historical perspectives inform "readers of the longstanding nature of the problem by presenting it in historical context" (Biklen & Casella, 2007). This historical component was significant in connecting some of the issues that women mathematicians in previous generations faced when dealing with race and gender to the current generation of women mathematicians. These various perspectives helped in the development of the MoS.

The Model of Success (MoS)

General Overview of the Model

There are two primary factors that comprise the MoS: extrinsic and intrinsic factors (Figure 1). The extrinsic factors are the external conditions that promote or inhibit success for African American women in mathematics, where the intrinsic factors relate to perceptions of self that mediate the educational experiences when pursuing a degree in mathematics.

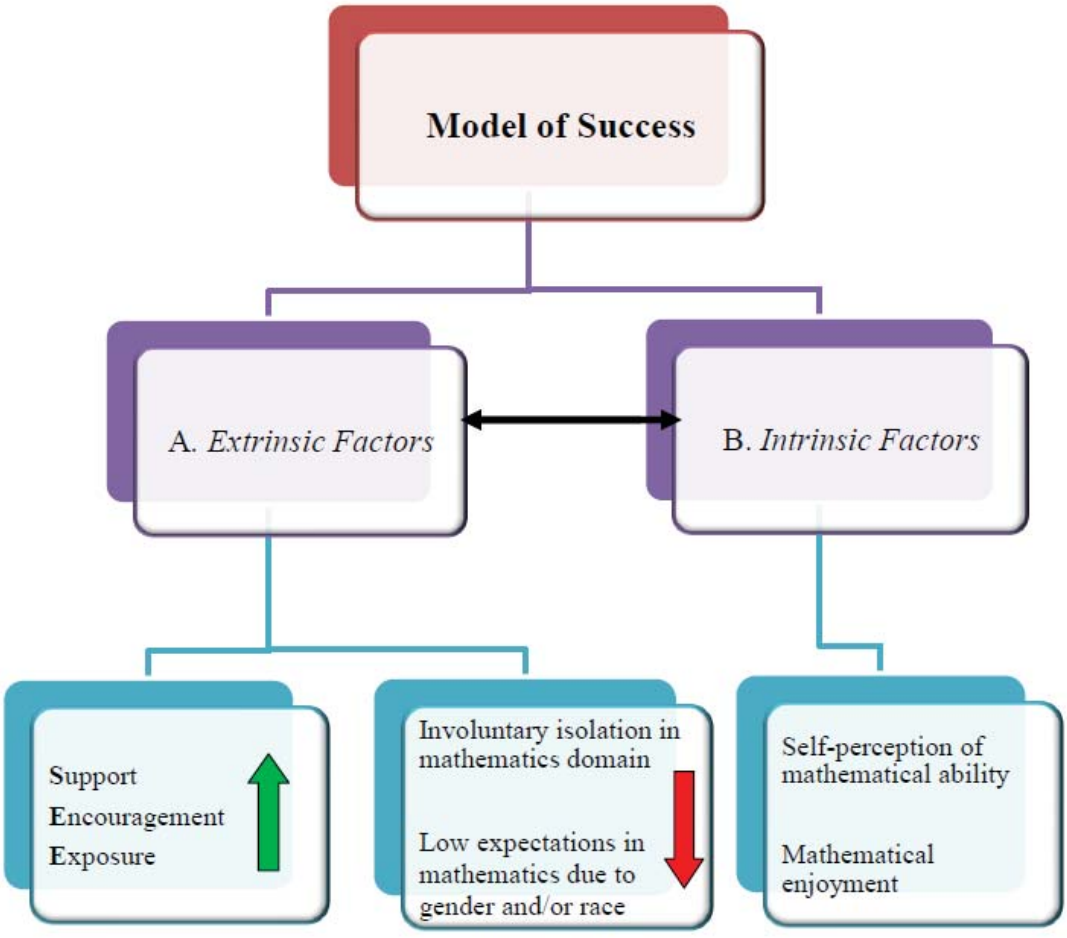

Figure 1. Model of Success (MoS) in Mathematics

Extrinsic Factors

There are certain extrinsic factors that were found to promote success in mathematics for African American women, including *support*, *encouragement*, and *exposure*—SEE factors. Support can take various forms in mathematics, although a primary form of support for African Americans is mentoring. That is, all of the women in the study and the women analyzed in the historical component had a mentor or role model and discussed their importance. The characteristics defining their mentors were: knowledgeable, encouraging, supportive, and showing a genuine enjoyment for mathematics. A few of the women claimed that having a mentor with the same race and/or gender helped to increase their self-esteem and self-efficacy in mathematics.

Peer support groups were another form of support. When peer support groups are fully effective they allow an exchange of knowledge between students and creates a safe space where students feel comfortable sharing their ideas and mathematical thinking even if it is not always accurate. The participants in the study discussed how support groups held everyone accountable for each other's successes and completion of the program. One participant states, "We all became a family. So, it made it so that no one wanted to leave, we got so close people didn't want to leave. So, that kind of kept us all through the program." The structure of peer study groups can also allow everyone to bring different strengths and perspectives to a particular problem. Another participant claims, "You did not feel bad for something that you didn't know because you knew that somebody else understood and could explain it to you."

Encouragement also takes various forms, which include verbal praises and acknowledgements received from teachers, professors, parents, mentors, and other family members. Phrases of encouragement ranged from the more general "good job" and "way to go" comments to more specific comments that relates to the student on an individual level. Many of the women from the study discussed how important it was to hear verbal forms of acknowledgment regarding their success and achievement in mathematics. Often, their family members and mentors would encourage them to continue towards the completion of their terminal degree.

Exposure is a vital component to gain attention and attraction to the mathematics field. For the women in the study, exposure opportunities included undergraduate research experiences, summer research in the K–12 grades, after school and Saturday enrichment programs in mathematics and other STEM fields. The various programs and research experiences that the women were involved in helped them to better understand mathematical concepts, introduce them to experts in the mathematics and science fields, provide potential mentors, and offer insight into future career paths in mathematics. Additionally, several of the women mentioned exposure to mathematics before entering formal schooling. Many discussed activities they would play at home with family and extended family members. These activities ranged from building models, mathematical races, calculating various measurements, and solving mathematical riddles and puzzles. The above-mentioned SEE factors promote success of African American women in mathematics.

In contrast, two extrinsic factors were characterized as inhibitors to success by many of the African American women interviewed and women observed in the historical perspective—involuntary isolation and low expectations. Involuntary isolation referred to separation the women experienced from certain faculty members and students in their mathematics courses and communities. One woman discussed her undergraduate experience in a mathematics class and remembers being ignored by her teacher. "I was the only woman and the only African American in the class and the teacher refused to call on me, no matter how many times I raised my hand." From the women researched in the historical perspective many of them were also isolated from the mathematics domain and would occasionally submit solutions to mathematical proofs using a male's name as a pseudonym.

Low expectations due to gender and/or race were another component described by the women interviewed as possible deterrents from completing their terminal degree. The women described how perceptions of low expectations illuminated and it was often assumed by male faculty that women were weaker in their mathematical abilities. From an early age one of the women discussed how her teacher assumed she had been cheating on her mathematics tests since she was excelling at a level higher than anyone else in the class. Other factors the women discussed relating to low expectations due to gender and/or race were: faculty not caring whether they finish the program, meetings specifically for women and students of color describing other possible options besides obtaining a mathematics degree, and the faculty requesting exam grades only for African American women in mathematics courses.

Intrinsic Factors

Intrinsic factors in the MoS relate to how African American women perceive themselves, for example, as mathematicians. Developing and maintaining a positive self-perception of one's mathematical ability was found to promote success. Many of the women in this study recognized their abilities, i.e., perceived themselves to be high achievers in mathematics. Their strong beliefs in their mathematical abilities often stem from their parents or family members encouragement before entering formal schooling.

Another intrinsic factor of the MoS is mathematical enjoyment, i.e., appreciating mathematics and its aesthetic appeal. Mathematical enjoyment was often mentioned by

the African American women mathematicians. One woman described how mathematics was viewed as a gift to her. "I would get all of my homework done and math would be a present to myself." Other women described that doing mathematics problems were "fun" and "exciting."

Future Implications

The MoS is a continuation in finding ways to promote the growth and presence of African American women in mathematics. While this model was specifically designed for African American women, many of the ideas noted can be used in promoting the pursuit of higher degrees in mathematics in general. For the extrinsic factors listed, the goal is to increase the SEE factors. This can be done by increasing the different forms of support systems, encouraging students especially women and minorities to pursue mathematics fields, and exposing students to research and mathematical experiences in K–12. Furthermore, for the intrinsic factors one can find innovative and creative methods of instruction for mathematics especially in the earlier grades. This can help motivate students who may have otherwise avoided a career in mathematics. In looking at ways to decrease the extrinsic factors that can deter African American women from pursuing mathematics, one suggestion is to look at the norms of the institution or program to determine if low expectations exist due to gender and/or race. Researchers believe that having low expectations for minority students can promote negative peer effects where other peers of majority groups believe the teacher's claim and assume that minority students are inferior to them in their academic ability (Hoxby, 2002).

Although several of the factors stated in the model have been stated in various studies that explore the success of women and minorities in mathematics and other STEM fields, few integrate those factors into one structure. Thus, the MoS serves as a "type of analogy that imparts clearer and more distinct understanding of the phenomena" (Kielhofner & Burke, 1980). Implementation of the MoS can be done in various forms. Since different organizations and programs have been established to increase the number of women and minorities in mathematics and other STEM fields this model can serve as a guide to organizers and directors in addressing those issues that promote and/or inhibit success for African American women in mathematics. Furthermore, the MoS can function as a rubric for evaluating programs geared towards increasing the number of African American women in mathematics and other STEM fields. Although this model looks specifically at African American women, similar factors and characteristics may be applicable for other underrepresented groups in mathematics.

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Elementary Teachers' Beliefs of African Americans in the Mathematics Classroom

Christa Jackson
University of Kentucky

The underlying theme of the Equity Principle in the *Principles and Standards for School Mathematics* (NCTM, 2000) is all students can learn mathematics. Unfortunately, many African American students are consistently demonstrating low mathematical achievement and many educators refuse to acknowledge racial inequities faced by African Americans in the mathematics classroom. In this qualitative study, twelve elementary mathematics teachers from four school districts in the Midwest are interviewed about their beliefs about teaching African American students and teaching mathematics to African American students. The teachers in this study believe African American students can and do succeed in mathematics, which is contrary to the belief held by some educators that African American students cannot do outstanding work. The findings in this study reveal that mathematics teachers need productive beliefs specifically related to African American students, how African American students learn, and effective teaching practices for African American students in order to teach mathematics through an equitable lens.

Keywords: African American students, elementary, teachers' beliefs

Introduction

The underlying theme of the Equity Principle in the *Principles and Standards for School Mathematics* (NCTM, 2000) is all students can learn mathematics. Unfortunately, many African American students are consistently demonstrating low mathematical achievement (Lee, 2004; Lubienski, 2002) and many educators refuse to acknowledge racial inequities faced by African Americans in the mathematics classroom (Rousseau & Tate, 2003). Instead, they live in a "colorblind" society. Teachers upholding this colorblind ideology argue that good teachers are good for every student and equitable outcomes will automatically occur (Gay, 2000; Martin, 2007). However, this ideology contributes to ignorance on the impact of racism and racial issues in the mathematics classroom (Rousseau & Tate, 2003).

It is not only colorblind teachers who hold beliefs that do not facilitate the academic participation and learning of African American students. For example, some public school teachers hold the belief that African Americans are lazy and cannot learn (Martin, 2007), and about half of White Americans believe Blacks are unintelligent (Landsman, 2004; Smith, 1990). These beliefs may be grounded in the longstanding belief that Blacks were generations behind Whites with regard to skills and intelligence in an evolutionary sense (Anderson, 1988; Spring, 2005). These beliefs play a powerful role in the poor achievement of African American students, and lead to low expectations that deny access to problem solving and higher-order thinking skills in mathematics. Consequently, achieving equity in mathematics education, specifically in relation to African American students, requires teachers with productive beliefs. The purpose of this manuscript is to report the findings from a research study of elementary teachers' beliefs as it relates to the instruction of mathematics to African American students. The research questions underlying this study are:

What beliefs do elementary mathematics teachers have about (1) African American students, and (2) teaching mathematics to African American students?

Teachers' Beliefs

In a study done by Thompson (2009), a Mindset Questionnaire was administered to 143 Texas educators and 94 pre-service teachers in California. The study found that 94% in-service and 90% practicing teachers believed most teachers do not know how to work effectively with African American K–12 students, thereby hindering success. Furthermore, the questionnaire asked teachers (white and black), pre-service teachers, and administrators about the