



[Image description: Group of smiling young students of Color of various gender expressions, with a smiling masculine-presenting teacher of Color, in a STEM classroom.]



Equity by Design:

Relevance and Beyond:

**The Role of Socially Transformative Curriculum
in Science and Mathematics Education**

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Relevance and Beyond: The Role of Socially Transformative Curriculum in Science and Mathematics Education

We share a general view that African-American students face challenges unique to them as students in American schools at all levels by virtue of their social identity as African-Americans and of the way that identity can be a source of devaluation in contemporary American society. We believe, as we all argue, the contemporary conversations about African-American achievement ignores these social facts in ways that seriously distort debate (Perry et al., 2003, p.vii).

Views of Black Learners

In his piece *Learning Mathematics while Black*, Martin (2012) states that while Blackness is not the only aspect of Black learners' sense of self and development, the social construction of Blackness is relevant to their academic identity development and their lived realities as Black people. That is, although "[m]eanings for Blackness have always permeated the prevailing racial ideologies, institutional practices, social arrangements, and opportunity in the U.S. society, these meanings are no less relevant to Black children's mathematical [science] development and lived realities" (Martin, 2012, p. 50). Hence, the learning experiences of Black children are stymied by race and racism (Mutegei, 2011; Spencer, 2009).

In contemporary society, Black students and their families are often framed through a deficit lens and reduced to negative stereotypes. Terms such as "at-risk," "lacking interest," "not valuing school," "unteachable," and "dysfunctional" are a

few descriptions used in both educational policy and research (Martin, 2012). For decades, in research about racial disparities in mathematics and science learning, the intelligence of Black students is often underemphasized, while their underachievement is overemphasized (Berry et al., 2011; Martin, 2012). While many are comfortable acknowledging that racial disparities exist in Black students' performance and their teaching and learning experiences, most do not connect those disparities to the impact of racism (Spencer, 2009).

Impact of Views of Black Learners

Oftentimes, teacher beliefs and practices are impacted by the deficit views and stereotypes which exist around Black learners' intelligence, and who they are as people (Martin, 2012; Morton & Smith-Mutegei, 2018; Tate, 1997). In multiple research studies, Black young women attributed institutional neglect to their lack of access to educational opportunities. For these Black young women, institutional neglect manifested itself through denial of

placement in advanced courses and quality curriculum, receiving low quality instruction, and lack of investment in the cultivation of their academic success (Neal-Jackson, 2018). Another way that institutional systems hinder students of Color's access to educational opportunities is through the disproportionate placement in special education.

Since the 1970's the United States Office of Civil Rights (OCR) has reported an overrepresentation of students of Color in certain disability categories. Since most special education eligibility programs start with teacher referral, and teacher bias and stereotypical beliefs influence teachers perception of students' ability, students from racially and linguistically diverse backgrounds are more likely to be labeled with a disability. Once labeled, learners are often placed in more restricted or segregated special education classes, and general education classes that perpetuate inequities (Ferri & Connor, 2005).

Experiences of Black Learners

In these learning spaces that perpetuate inequities, Black learners often endure dehumanizing learning experiences where the opportunity to learn mathematics and science in a rich, relevant, and rigorous environment is not afforded to them (Hill, 2010; Spencer, 2009). Oftentimes, Black learners' funds of knowledge (Gonzalez et al., 2005) are not valued, they do not see themselves in the curriculum, or see how they can use the content to address the lived realities or the social problems they and their communities face (Gutiérrez, 2018). In most mathematics and science classrooms, learners are not empowered or equipped to

understand that mathematics and science are liberatory tools that can help address racism, and improve the social condition of Black people, both locally and globally (Pitts-Bannister et al., 2017).

Redressing Experiences through Socially Transformative Curriculum

Implementing a socially transformative curricular (STC) approach opens the door to opportunities which value learners' experiences, interests, histories, and the history of their communities. Opportunities center around what Gutiérrez and Rogoff (2013) call *repertoires of practice*. These are opportunities that treat learners as members of "families, communities, society and



[Image description: Smiling feminine-presenting student of Color in a classroom, holding a recycling box.]

culture," all of which serve as sources of meaning, values, problems to address, and responsibilities (Maccleave & Eghan, 2010, p.10). STC allows learners to see themselves in the curriculum, find meaning

in the curriculum, and gain an understanding of how the curriculum can be used as a tool for personal and social change. Socially transformative STEM curriculum can empower students to use science and mathematics as liberatory tools.

What is Socially Transformative STEM Curriculum?

Curricular Approaches

When educators set about to plan curriculum, they inevitably have to answer the curriculum question popularized by Herbert Spencer (1911), "What knowledge is of most worth?" Curriculum theorists have identified types of approaches educators use in answering this question; these are called *curriculum approaches*. The predominant curriculum approach in modern Western society, and the one that most of us have been subject to, is cultural transmission. For an educator operating from a cultural transmission approach, the knowledge that is of most worth is the knowledge that represents "the best products of the intellectual culture" (Pratt, 1994, p. 9). This is the reason children spend so much time in school learning ideas that seem irrelevant to them (e.g., the Bohr model of the atom, the four nucleotide bases of DNA and which bases bond with each other, and whether the Paleozoic era comes before or after the Mesozoic era). Although the ideas seem irrelevant, groups of scientists and educators have gotten together and decided that these are the best ideas that have been produced in Western culture, and that these ideas should be transmitted or passed on to successive generations.

Social Transformation

Social transformation is merely a different curriculum approach. For an educator operating from a social transformation approach, the knowledge that is of most worth is the knowledge that positions learners to transform (or improve) their current social condition. In a broad sense, socially transformative STEM curriculum can be applied to any demographic group. However, the recent articulation of socially transformative STEM curriculum in mathematics and science education research is aimed at applying it to learners



[Graphic image description: Black protest fist holding sharpened pencils.]

of African descent. The three-part goal is to provide learners of African descent with curricular experiences that help them to (a) recognize the role and pervasiveness of systemic racism in their current condition, (b) understand how systemic racism is maintained, and (c) help them to develop tools for countering it.

As a curriculum approach, socially transformative STEM curriculum faces two distinct challenges. The first is that it runs counter to the prevailing curriculum approach. So, implementing it requires that we be socially transformative educators in a cultural transmission world. All of the structures currently in place (e.g., curricular material; standards which guide instruction; district, state and national assessments; pre-service and in-service professional development) are designed to support cultural transmission. The second challenge is that STEM carries an aura of being above social ills (Gutstein, 2006). Science, technology, engineering, and mathematics are not typically regarded as subject areas that influence, or are influenced by, sociopolitical problems (Gutiérrez, 2013; Zeidler, 2016).

Why is Socially Transformative STEM Curriculum Important?

For learners of African descent, socially transformative STEM curriculum is critical because it speaks to the most basic and immediate needs of their communities. The conditions under which people of African descent currently exist can be characterized as pervasively deficient (Mutegi, 2011), which is to say that they have fewer of those things that are good (e.g., higher net worth, more effective medical treatment, higher home ownership, etc.) and more of those that are bad (e.g., higher incarceration rate, higher unemployment, higher mortality, etc.). Socially transformative STEM curriculum is envisioned as a means of helping people who are socially and historically situated in positions of pervasive disadvantage to correct that social condition (Mutegi, 2011).

To put this in context, using the cultural transmission approach to curriculum, we take children who we know are less likely to receive good medical treatment, for example. We then spend an inordinate amount of time forcing these children to learn esoteric life science concepts (e.g., the formulas for photosynthesis and cellular respiration, oxidative phosphorylation, or the classes of invertebrates). After learning these concepts, the learners still face the reality of living in a world where they are less likely to receive good medical treatment, and by virtue of their education, they are in no better position to influence the quality of care that they receive.

Using the socially transformative approach to curriculum, we would spend more instructional time addressing concepts that would position learners to influence the quality of care they receive positively. For example, we might seek to answer questions such as, "What are the symptoms of lupus, diabetes, cancer, or sickle cell? What are the *known* causes of these illnesses? What are the *suspected* causes? What tests can medical professionals run to diagnose these illnesses? How do these tests work?" After exploring and answering these questions, learners are in a much better position to influence the quality of care that they receive. What is more, in the course of answering these questions, it is likely that learners will be exposed to many of the concepts that are part of the cultural transmission canon.

Putting Socially Transformative STEM Curriculum in Practice

When we attempt to improve achievement in African American student, we must take into consideration not just academic issues, but issues of psychological trauma caused by living in a society in which black people have been stigmatized (Delpit, 2012, p. 20).

Content Development

Mutegi's (2011) 5c's model of socially transformative STEM curriculum centers around five areas of mastery for learners. The five levels are *content, currency, context, critique, and conduct*. *Content* speaks to positioning students to master the content. Students are empowered with a conceptual understanding of the content, and can apply their skills and knowledge to multiple problem situations. *Currency* positions students to understand how the content relates to humankind. The content becomes connected and relevant, rather than a set of disjointed facts lacking connections to students' lived experiences. *Context* speaks to students understanding how the content connects with and impacts people of African descent. *Critique* positions students to know how they can use the content to understand how systemic racism works. *Conduct* is the last area of mastery, and it empowers to apply their knowledge as a tool for personal and social change.

When creating curricular content to address the five areas of mastery, educators should consider the questions found in Table 1 (p. 8).

The work of Morton and Smith-Mutegi (2018), Mutegi (2011), and Pitts-Banister, et al. (2017) provides examples of mathematics and science curriculum units based on the 5c's model. In their work, Morton and Smith-Mutegi (2018) describe a financial simulation completed by girls ages 8-17 called "Get Your Money Right." Table 2 (pp. 9-10) describes how "Get Your Money Right" addresses the five levels of mastery within the socially transformative STEM curriculum (STC) framework.

Individual Coaching for Teachers

One strategy that Mutegi and members of his research lab have begun implementing to advance socially transformative STEM curriculum is individual coaching for practicing STEM teachers. The way the coaching model (Teemant et al., 2011) works is that the team a) identifies practicing teachers who have an interest in socially transformative STEM curriculum, and a commitment to the well-being of learners of African descent; (b) provides a short course, orienting teachers to the basic principles of socially transformative STEM curriculum; and (c) conducts a series of classroom observations of the teachers, interspersed with coaching sessions.

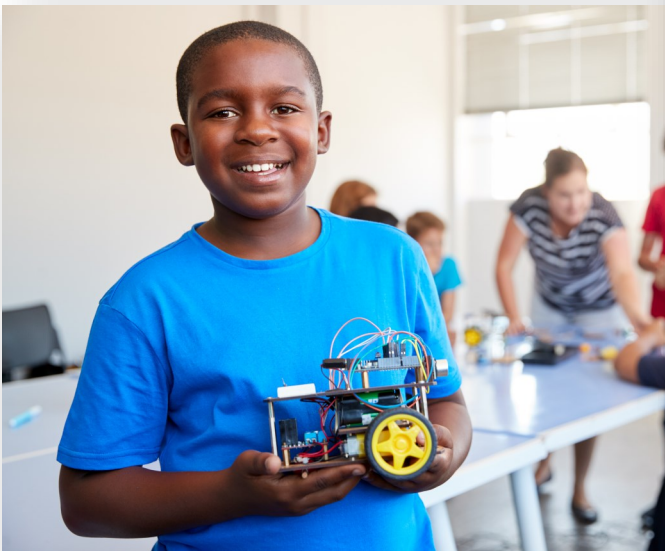
In the first step, *identifying teachers*, it is vital that teachers want to engage in coaching, and receive some intrinsically important benefit from it. Because schools are not set up to support socially transformative curriculum, much of what teachers do through our coaching will require additional time, resources, and planning. It is not likely to be successful if teachers feel as though it is being thrust upon them.

In the second step, *completing a short course*, teachers are introduced to the theoretical foundation of the model, as well as the practical implementation of the model. The short course that teachers complete allow them opportunities to engage in socially transformative STEM lessons as learners, and begin to conceptualize and plan their own socially transformative STEM lessons.

In the third step, *classroom observations*, teachers meet with the coach for a pre-observation session, in which they work with the coach to determine the goals for the coming lesson. Following the observation, teachers meet with the coach again for a post-observation debrief in which both the teacher and the coach share their reflections on the lesson. Throughout this process, the coach's role is to facilitate and support the teachers' efforts to incorporate socially transformative STEM curricular content.

Concluding Thoughts

Black children's mathematics learning experiences are racialized because of the historical and social realities surrounding their relationship with the dominant culture (Spencer, 2009). Their experiences in mathematics and science classrooms often dehumanize who they are as a Black person learning mathematics and science. Integrating a socially transformative STEM curricular approach in mathematics and science is one way to rehumanize the mathematics and science learning experiences of Black students, empowering them to disrupt systems of racism that creates social ills for both them and their communities.



[Image description: Left photo: young masculine-presenting student of Color smiling and holding a robot vehicle. Right photo: young feminine-presenting student of Color looking intently at a group of test tubes.]

About the Authors

Dr. Crystal Morton is an Associate Professor of Mathematics Education in the Department of Urban Teacher Education at IUPUI School of Education, where she serves as the Associate Dean of Research and Faculty Development. She also serves as Associate Director of Research for the Great Lakes Equity Center and board member for TechPoint Foundation for Youth, and is the founder and director of Girls STEM Institute.

Dr. Morton's scholarly work focuses on secondary mathematics education, emphasizing the role of informal STEM learning in fostering equitable and transformative mathematics teaching and learning experiences. She primarily examines the learning experiences--specifically mathematics learning experiences--of Black girls in grades 3-12.

As a former high school mathematics teacher, she is passionate about providing historically marginalized populations opportunities to become the next generation of STEM professionals, leaders and decision-makers.

Dr. Jomo W. Mutegi is an Associate Professor of Science Education at Old Dominion University (ODU), and President-Elect of the National Association of Research in Science Teaching (NARST), which is the most prominent international association of science education researchers in the world. Dr. Mutegi's research aims to (a) better understand and disrupt systemic racism in the STEM education of people of African descent; and (b) advance practical curriculum for STEM learners. His work appears in several respected journals including: *Journal of Research in Science Teaching*, *Science Education*, *Teachers College Record*, and *The Science Teacher*. As Principal Investigator of the Mutegi STEM Learning Lab, Dr. Mutegi has received over \$3.6 million in external grant funding.

Guided by the counsel of Dr. Amos Wilson who reminds us that, "The function of education is to secure the survival of a people," Dr. Mutegi works through the Mutegi STEM Learning Lab to conduct research and create educational materials that contribute to the survival of African people.

Dr. Demetrice Smith-Mutegi is an Assistant Professor in the Department of Teaching and Learning at Old Dominion University in Norfolk, Virginia. She teaches K-12 foundation courses, and secondary science and math methods to preservice teachers. Before entering higher education, she served in North Carolina, Maryland, and Indiana public schools as a STEM educator.

Demetrice's current research interest lies in investigating the motivations, beliefs, and experiences of Black students in STEM, as well as factors that influence Black STEM teachers' career decisions. She also collaborates on interdisciplinary teams to study how informal STEM learning experiences affect Black girls and families. Demetrice has completed studies in science education at Morgan State University (Ed.D.) and East Carolina University (M.A.T.), as well as an undergraduate degree in Biology from the University of North Carolina at Chapel Hill.

Tables

Level of Mastery	Question to Consider
Content	“What is X?” Here X could represent any mathematics or science concept.
Currency	“How and where is X relevant to mankind in modern life?”
Context	“In what ways is X important to people of African descent?”
Critique	“How can my understanding of X help me to understand systemic racism?”
Conduct	“How can I use my understanding of X to improve the social conditions of people of African descent?”

Table 1: 5c’s Mastery Questions for Socially Transformative STEM Curriculum - Mutegi (2011)

Tables (cont.)

Level of Mastery	Question to Consider	The ways “Get Your Money Right” Addresses Levels of Mastery
Content	“What is personal finance ?”	Girls applied problem-solving and computational fluency skills to complete the financial simulation.
Currency	“How and where is personal finance relevant to mankind in modern life?”	Financial simulation focused on developing and maintaining a household budget.

Table 2: STC Example – Get your Money Right- (Morton & Smith-Mutegi, 2018)

Tables (cont.)

Level of Mastery	Question to Consider	The ways “Get Your Money Right” Addresses Levels of Mastery
<p>Context and Critique</p>	<p>“In what ways is personal finance important to people of African descent?”</p> <p>“How can my understanding of personal finance help me to understand systemic racism?”</p>	<p>Discussions and activities facilitated to help increase girls’ understanding of how systemic racism and gender discrimination serve as barriers to their financial wellness and the financial wellness of their families and communities.</p> <ul style="list-style-type: none"> • A sample of discussion and activity topics includes income and wealth disparities, predatory lending practices, wage disparities, paying taxes, and understanding the tax code.
<p>Conduct</p>	<p>“How can I use my understanding of personal finance to improve the social conditions of people of African descent?”</p>	<p>The simulation provided experiences with real-life tools to help girls understand how to better prepare for a healthy financial future for themselves and their families and communities.</p>

Table 2 (cont.): STC Example – Get your Money Right- (Morton & Smith-Mutegi, 2018)

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