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By Adrienne Coleman[*]

According to the National Science Foundation, "the U.S. STEM workforce must be considered in the context of an expanding and vibrant global scientific and technological enterprise" (2014). "The National Academy of Sciences further suggests that, without the participation of individuals of all races and genders, the increasing demand for workers in STEM fields will not be met, potentially compromising the position of the United States as a global leader" (2014). The stark reality is that there are a disproportionate number of Black and Latinx students who lack the access and exposure to become STEM-literate. In order for the U.S. to remain a global STEM leader, an intricate look at STEM inequity on a national scale must occur and diversifying the STEM education to career pathway must be a priority. The Illinois Mathematics and Science Academy sought to gain a better understanding of how to diversify this STEM education to career pathway. Thus, a study was conducted on the motivation of Black and Latinx students to engage in STEM as well as two Diversifying STEM Think Tanks held, to understand and address the racial STEM divide. From the perspectives of 415 STEM Stakeholders (students, parents, professionals, and educators) the D-STEM Equity Model to diversify the STEM Education to Career Pathway with national implications and global scalability was developed. This model suggests "diversifying STEM policies" need to be developed that mandate funding for racially-based collaborative STEM initiatives to be implemented, that work towards achieving equity by addressing the identified problems collectively and integrating factors of Black and Latinx student STEM motivation into STEM programming as well as encourage culturally responsive STEM educator training.

Keywords: STEM, diversity, equity, race/ethnicity, innovation

Introduction

According to the National Science Foundation, "the U.S. STEM workforce must be considered in the context of an expanding and vibrant global scientific and technological enterprise" (2014). As a global powerhouse, the United States (U.S.) has demonstrated leadership in economics, military, political influence, innovation, and culture/lifestyle (Bremmer, 2015). Specifically as it relates to innovation, the U.S. has superb scientific institutions of higher education and is home of the majority of tech companies in the world (Bremmer, 2015). Despite this, research suggests that the United States is struggling to maintain its competitive edge in innovation, especially in the global STEM (science, technology, engineering and mathematics) space. "For over a decade, indicators data have shown that other nations, led by China, South Korea, and Brazil have been increasing their innovation capacity by investing heavily in higher education

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as well as research and development" (Organisation for Economic Co-Operating and Development, 2007).

While other nations continue to strengthen their innovation practices and improve STEM education, the U.S. is lagging behind; the World Economic Forum ranks the U.S. 47th worldwide in the quality of its math and science education (Miller & Horrigan, 2014). This is evident in the 2012 Programme for International Student Assessment (PISA), in which American 15 year-olds ranked 26th in math and 21st in science, with an average score of 481 and 497; while Shanghai-China ranked first, with an average score of 613 and 580 (Organization for Economic Co-Operating and Development, 2014). This U.S. Global STEM education inequity is further evident in the 2015 Trends in International Mathematics and Science Study (TIMSS), which found that the United States ranked 10th in 4th and 8th grade math, 10th in 4th grade science and 11th in 8th grade science (National Center for Education Statistics, 2015). These trends indicate the U.S. is in dire need of improving the quality of STEM education and ensuring that everyone has access in order to be competitive in the global STEM economy (Miller & Horrigan, 2014).

In a study conducted by the National Science Board, some analyst "contend that the United States has or will soon face a shortage of STEM workers" (National Science Foundation [NSF], 2014). There are several indicators that suggest STEM jobs are growing rapidly in the U.S. and are scheduled to increase by 17 % by 2024 (Coleman, 2016; Department for Professional Employees [DPE], 2016; U.S. Department of Commerce [DOC], 2011; Department of Education [DOE], 2016). With such increased growth being forecast for the STEM industry, if the U.S. is unable to meet this demand, its' global leadership status will be jeopardized. Recent analyses indicate that during the next five years, major American companies will need to add nearly 1.6 million employees to their workforce; 945,000 who are STEM-literate and 635,000 with advanced STEM knowledge (DOE, 2016). This year alone, technology companies, such as Facebook, Amazon, and Apple, will need to hire for more than 650,000 (Ouimet, 2015). Considering this potential rapid growth in the STEM space, the U.S. global status of STEM education and the challenge of remaining a global leader, the United States must address the inequities in STEM education and prioritize the development of a STEM-literate workforce.

The increasing demand for STEM-skilled professionals is a global trend, so diversifying the STEM education to career pathway will benefit the global STEM market (Richards, 2018).

"The additional benefit of developing a STEM-literate and well-trained domestic workforce is that this ensures that we adequately address challenges related to healthcare improvement, national production capacity, and research excellence" (Allen-Ramdia & Campbell, 2014). The reality is that the future workforce will rely much less on having content-based knowledge and more on possessing the skills needed to analyze, reflect, and solve difficult problems. "The learning and doing of STEM helps develop these skills and prepare students for a workforce where success results not just from what one knows, but what one is able to do with that knowledge…a strong STEM education is becoming

increasingly recognized as a key driver of opportunity, and data shows the need for STEM knowledge and skills will grow and continue into the future" (DOE, 2016). With readily available resources, the ability to create new knowledge through STEM skills for innovative solutions to solve the pressing problems of society is paramount.

If the U.S. wants to maintain its' status as a global leader in STEM, be competitive in the STEM space, and address global challenges; diversifying the STEM education to career pathway must be a take precedence. "STEM and diversity are integral to the sustainability of our schools, the innovation of our businesses, the prosperity of communities and the global competitiveness of our economies" (Richards, 2018). The U.S. must take intentional and strategic action to not be left behind in the innovative, global STEM space. The duration of this paper will take an intricate look at the global and national value of Diversifying STEM in the United States of America. We will examine the racial inequities in the STEM education to career pathway, gain an understanding of why these inequities exist, reflect on how these inequities have been addressed and introduce a model to address these racial inequities; ultimately diversifying the STEM Education to Career Pathway with both national and global implications.

Literature Review

"The National Academy of Sciences suggests that, without the participation of individuals of all races and genders, the increasing demand for workers in STEM fields will not be met, potentially compromising the position of the United States as a global leader" (NSF, 2014). In order for the U.S. to remain a global STEM leader, an intricate look at STEM inequity on a national scale must occur. The stark reality is that a disproportionate number of people of color, particularly Black and Latinx persons, are even further away from becoming STEM-literate and having the ability to thrive in a hyper-competitive, global marketplace (Miller & Horrigan, 2014). "The nation has persistent inequities in access, participation, and success in STEM subjects that exist along racial lines, which threaten the nation's ability to close education and poverty gaps, meet the demands of a technology-driven economy, ensure national security, and maintain preeminence in scientific research and technological innovation" (DOE, 2016). This leads to the underrepresentation of Black and Latinx persons in STEM education and careers.

The 2013 U.S. Census Bureau indicates that Black and Latinx populations are underrepresented in STEM, with them each making up less than 10% of the STEM workforce; while White individuals are overrepresented, making up 70% of the workforce (DPE, 2016; Landivar, 2013). In terms of readiness to enter a STEM major and ultimately a career, only 6% of Black students and 13% of Latinx students, compared to 36% of Whites and 53% of Asians, are actually prepared (Coleman, 2016). Among students taking the 2017 National Assessment of Educational Progress (NAEP), the average math test score gap between Black and White fourth graders was 25 points and for eighth grade students, the gap was 33 points, while the math gap between White and Latinx students was 19 points

for fourth graders and 24 points for eighth graders. Asians outperformed all other racial and ethnic groups in both grades, in mathematics (National Center for Education Statistics [NCES], 2018). In addition, NAEP demonstrates that only 13% of Black students and 20% of Latinx students scored at or above proficiency in 8th grade mathematics; compared with 44 percent of White students and 62 percent of Asian students (NCES, 2018). Additional data suggests that in 2013, on the math component of the SAT exam, college-bound Black and Latinx students scored disproportionately lower than their White and Asian Counterparts; Black students averaged 429, Latinx students averaged 459, White students averaged 534 and Asian students averaged 597 (Miller & Horrigan, 2014). One might assume that Black and Latinx students have no inclination to enter STEM; however, research actually suggests that they have both an interest and intent to pursue STEM more often than their White counterparts (Byars, 2013; Educational Research Center of America [ERCA], 2016; Riegle-Crumb & King, 2010). According to a study conducted by the Research Consortium on STEM Career Pathways, 59% of Black students and 62% of Latinx students have STEM career aspirations (ERCA, 2016). This data suggests that racial inequity exists in STEM education, unrelated to aspiration, needs to be addressed to enhance global STEM sustainability.

Not only does diversifying STEM in the United States assist with global leadership, but it will also help Black and Latinx communities with economic growth, leading to a better standard of living (Miller & Horrigan, 2014). Workers in STEM occupations earn more on average than their counterparts in other jobs, regardless of their educational attainment. (DOC, 2011). Considering this, Latinx and Black households earned a median income of $38,624 and $32,229, respectively, in 2011; however, today's median wage for Black persons employed in U.S. STEM jobs is $75,000 and around $77,000 for Latinx persons, (Coleman, 2016; Ouimet, 2015). According to the U.S. Department of Education Office for Civil Rights', the STEM fields "are the gateway to America's continued economic competitiveness and national security, and the price of admission to higher education and higher standards of living for the country's historically underrepresented populations" (2014).

Being that the United States is such a global force, one should be curious as to why racially based STEM education and career inequities exist. Research suggests that it is a multifaceted problem resulting from; a lack of exposure to STEM in K-12 education, mathematics phobia, students' misperceptions of what science is, lack of real-life application of science, lack of motivation to succeed, and peer pressure that devalues high achievement (Coleman, 2016). Other sources have indicated the issue of inadequate funding, "favoring schools and communities that have access to the most resources, knowledge, and expertise", which typically does not include the Black and Latinx communities (Riegle-Crumb & King, 2010). In addition, strong STEM pedagogy and resources are typically lacking in these schools and there's an inclination to "address a perceived deficit with the student, rather than a focus on changing the system and delivery of STEM instruction to more effectively support and draw on students' strengths" (Henderson & Lawson, 2015). This is evident in the deficit mind-set that exists

with school district professionals related to poorly resourced schools, especially in STEM (Robinson, personal communication, June 19, 2018). Google conducted a study to gain an understanding of who was less likely to pursue computer science and why. The study concluded that Black and Latinx students were less likely to pursue computer science for the following reason: lack of exposure to computer science, lack of opportunity to learn computer science, lack of encouragement from others to learn and lack of computer science role models (Google Inc. & Gallup Inc., 2016). Additional research suggests other social and environmental factors, including college affordability, lack of self-confidence, feelings of isolation, and having lower expectations for students of color leads to a lack of diversity in STEM (NSF, 2014; Riegle-Crumb & King, 2010).

These lower expectations are a result of implicit bias, "when teachers' hidden attitudes and beliefs about students are based on race, ethnicity, and/or gender, they may unwittingly communicate negative messages to their Black, Brown, and Female students about their abilities to tackle STEM subjects" (Holsington, 2017). A prevalent attitude of bias towards Black and Latinx students is that they do not have the intellectual capacity to think spatially or scientifically (Byars-Winston, 2013). An outcome of this bias is Black/Latinx groups are not provided with STEM career information as often as their White and Asian counterparts (Byars-Winston, 2013). This is evident in Silicon Valley, which "is still too white, too male, and too focused on solving the problems of the young, single, and wealthy," said Owen Grover, the senior vice president and general manager of iHeartRadio (Meyer, 2015). Thus, it is suggested that diversifying STEM beyond race, to be more inclusive of low-income individuals and females, would be valuable. "The question of diversity is not just one about the numbers, or even a question about the culture of hostility and willful exclusion toward diversity for Black and Latinx people…it's about the deep level of comfort with being in all-white spaces (or only-white and Asian spaces), and not understanding the impact of that exclusion on the work and society" (Meyer, 2015).

To combat this racial STEM divide, an evidence-based STEM pathway must be established. Loma Linda University evaluated their Summer Health Disparities Research Program to determine its' effectiveness; finding that a focus on self-efficacy enhances STEM identity and leads to a stronger STEM career commitment (Salto, Riggs, Casiano, & De Leon, 2014). "The critical development of science self-efficacy as it influences the development of deeper measures of integration is supported by Estrada-Hollenbeck's work that found that while self-efficacy was related to identity and values, the relative influence of each on long-term STEM career commitment may be mediated by the progression of the student through the academic pipeline" (Salto et al. 2014). The National Science Foundation further states that there must be a focus on strengthening the STEM workforce using the following approach:

- Monitor and assess the condition of workforce pathways and identify risks and challenges to them,
- Ensure that all individuals have access to high quality education,

- Address roadblocks to the participation of groups traditionally underrepresented in STEM (2014).

This is consistent with the U.S. Department of Education STEM 2026 challenge, which places an emphasis on societal and cultural images and environments that promote diversity and opportunity in STEM, put this way:

> *In STEM 2026, how STEM is messaged to youth and their families is transformed. Research shows that repeated exposure to images, themes, and ideas affect people's beliefs, behaviors, and attitudes. In STEM 2026, popular media, toy developers, and retailers consider issues of racial, cultural, and gender diversity and identity in portrayals of STEM professionals and STEM-themed toys and games. These images counter historical biases that have prevented the full participation of certain groups of individuals in STEM education and career pathways. These portrayals include diverse pictures, descriptions, or images of what STEM work entails, including the array of jobs and activities that use STEM; and who is seen doing and leading STEM-related work. Communities and youth in all neighborhoods and geographic locations around the country are equally exposed to social and popular media outlets that focus on STEM, and a wide diversity of STEM-themed toys and games that are accessible and inclusive and effectively promote a belief among all students that they are empowered to understand and shape the world through the STEM disciplines* (DOE, 2016).

Methodology

The Illinois Mathematics and Science Academy (IMSA), a residential high school for gifted/talented students, sought to gain a better understanding of how to diversify the STEM education to career pathway. IMSA conducted a study on the motivation of Black and Latino students to engage in STEM as well as held two Diversifying STEM Think Tanks to understand and address the racial STEM divide. These studies are rooted in Critical Race Theory (CRT), which attempts to understand American education and reform, acknowledging the unique perspective and voice of people of color as victims of oppression in racial matters and valuing their storytelling as a legitimate way to convey knowledge (Khalifa, Dunbar, & Douglas, 2013). Qualitative methodologies were employed allowing participants to share their stories related to the intersection of race and STEM. The 415 participants included students, parents, educators, professionals, and community organizations who are all actively engaged in STEM.

For purposes of these studies, STEM Education was defined as:

> *"an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development*

> *of STEM literacy and with it the ability to compete in the new economy"* (Gubbins et al., 2013)

The initial study focused on the motivation of Black and Latinx students' engagement in STEM education, with the premise that understanding the motivation factors to inform STEM programming specific for Black and Latinx students may lead to a more diverse STEM education to career pathway. Participants yielded from the Illinois Mathematics and Science Academy, the James R. Jordan Foundation, Biostatistics and Research Awareness Network, Inc. and the Diversity Initiatives in Research for Underrepresented Minorities, as well as from three geographic locations including Illinois, Ohio and Washington, D.C. This included 106 high school students, 86 middle school students, 27 STEM educators, 51 parents and 11 college students; a total of 281 participants. Through a design of interviews with adult participants and focus groups with student participants, the student participants were asked the following questions:

- Discuss your intrinsic motivation ("behaviors performed out of interest and enjoyment") as it relates to you being a student engaged in STEM education and provide examples in which your motivation to engage in STEM was developed…
- Discuss your extrinsic motivation ("behaviors carried out to attain contingent outcomes") as it relates to you being a student engaged in STEM education and provide examples in which your motivation to engage in STEM was enhanced.

While the STEM educators and parents were asked the following questions:

- What do you perceive to be the intrinsic motivators ("behaviors performed out of interest and enjoyment") that lead Black and Latinx students to engage in STEM education…provide examples in which this motivation was observed?
- What do you perceive to be the extrinsic motivators ("behaviors carried out to attain contingent outcomes") that lead Black and Latinx students to engage in STEM education…provide examples in which this motivation was observed?

With an enhanced understanding of STEM motivational factors in Black and Latinx students, IMSA sought to then gain a more informed perspective of the racially-based problems that serve as barriers to diversifying STEM with the goal of developing an approach to address those barriers. Thus, IMSA held two Diversifying STEM Think Tanks with the following goal:

- To understand from the perspectives of STEM professionals, Educators, and Diversity/Inclusion Officers strategies to diversify and strengthen the STEM education to career pipeline.

There was a combined total of 134 STEM professionals, educators, and affiliates from 64 organizations who shared their perspectives on diversifying STEM (see table 1 below):

Table 1. Diversifying STEM Think Tank Organization Participants

Aceism Creative Illustration and Design, Inc.	Chicago Public Schools	Grace United Methodist Church	National Society of Black Engineers	The Illinois Mathematics and Science Academy
African American Heritage Advisory Board	Citi	IMSA Parents Association	Northwestern University	The Morton Arboretum
Alpha Alpha Sigma Zeta Chapter of Zeta Phi Beta Sorority, Inc.	Combat Training	IN2	Oswego School District 308	The Office of the Inspector General
Aurora Chamber of Commerce	Crete Monee Middle School	Indian Prairie School District #294	Plano CUSD 88/P.H. Miller Elementary School	The University of Chicago - Institute for Molecular Engineering
Aurora University	DePaul University	International Studies Abroad Program	Project SYNCERE	U-46
Baxter Healthcare Corporation	District 365U	John T. McCutcheon Elementary School	Resilient Mind Consulting	Union of Concerned Scientists
Bethel New Life Church	DuPage County Regional Office of Education	Kane County Sheriff's	Roosevelt University	Unity Partnership, NFP
Bridging the Gap	Educational Opportunity Program – U.S. Department of Education	LaCrosse Central High School	Saratoga Elementary School	University of Wisconsin - Madison
British Petroleum	Fermilab	Lewis University	Society of Hispanic Professional Engineers	United States Air Force
Byron CUSD 226	Fischer Middle School	Metea Valley HS	Stanford University	Washington University in St. Louis
Carver Military Academy	Girls 4 Science	Mettler Toledo	Staples	West Aurora School District 129
Caterpillar Inc.	Girls IN2 STEM	Murray Language Academy	Take Your Place, Inc.	Yorkville Middle School
Chicago Public Library Foundation	Goodwin Elementary	National Association for the Advancement of Colored People	Technology For Women, Inc.	YWCA Aurora

Regarding the format of the Diversifying STEM Think Tank, participants first heard from a group of STEM experts who focused on diversifying STEM, then had small groups discussions focused on identifying and addressing the barriers related to the lack of diversity in STEM education and careers. The first Think Tank consisted of a panel of professionals that included:

- Dr. Michael Horn, Assistant Professor in Computer Sciences at Northwestern University
- Dr. Anna Kaatz, Director of Computational Sciences at Center for Women's Health Research at University of Wisconsin-Madison
- Dr. Terrence Mayes, former Associate Dean, Graduate Education and Director at Stanford University
- Dr. Norman "Storm" Robinson III, Panel Moderator and Executive Director of Professional Field Services at the Illinois Mathematics and Science Academy
- Mr. Mike Salazar, President of the Society for Hispanic Professional Engineers
- Dr. Lateefah Stanford, Senior Scientist—Separations and Mass Spectrometry at British Petroleum

Participants were asked the following question during the small group discussion component of the Think Tank:

> The literature suggests that there is racially-based gap STEM majors/career gap in which Black and Latinx students do not major in or enter STEM fields as often as their White and Asian counterparts…Why do you think this racially-based STEM gap exists?

During the second Diversifying STEM Think Tank, the results from the initial event in which problems were identified was shared with participants, along with specific data on the actual number of Black and Latinx professionals engaged in STEM education and careers. STEM professionals then shared their STEM-related experiences as well as how they have contributed to diversifying STEM in the format of STEM Talks; modeled after TED (Technology, Entertainment, Design) Talks, "short, powerful talks" (2018). The STEMTalks experts included:

- Dr. Adrienne Coleman, STEMTalks Moderator and Director of Equity and Inclusion at the Illinois Mathematics and Science Academy
- Dr. Don Dosch, Biology Faculty at the Illinois Mathematics and Science Academy
- Dr. Brian Nord, Associate Scientist in Fermilab's new Machine Intelligence Group
- Dr. Kelly Page, IMSA Fellow, Communications and Learning Consultant. Social Design Ethnographer. Research Scientist. Founder and Curator of Grateful4Her

- Dr. Kenyatta Ruffin, U.S. Air Force Major and Founder of Legacy Flight Academy *(The Legacy Flight Academy is an independent, 501(c)(3) non-profit organization. The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement)*
- Dr. Anita White, PROMISE (PRoviding Opportunity in Math and Science Enrichment) Director and Chemistry Faculty at the Illinois Mathematics and Science Academy

After being informed about the overall problem and hearing the stories of STEM professionals, small groups were given a specific problem, defined in the initial Think Tank and asked to discuss the following:

> *Based on this definition, what strategies to address the problem should be implemented and why? Let's think about this from three different perspectives, educational institutions, community organizations, and the STEM industry. Recommend policies to be adopted.*

Below are images of marketing utilized to promote the Diversifying STEM Think Tanks:

Figure 1. Diversifying STEM Think Tank Marketing

Data collected from the initial study on STEM Motivation and the two Diversifying Think Tanks was transcribed and analyzed utilizing software transcription and word analysis programs, along with a qualitative management system. Then an inductive analysis process was conducted, which identified patterns and unconvered concepts; "ultimately, the qualitative data analyst aimed to create a shared understanding that forms a coherent structure between the studies, a unified whole" (Suter, 2012). Thus, a model to diversifying the STEM education to career pathway was developed.

Results

Factors that motivate Black and Latinx students to engage in STEM

The initial study on the factors that motivate Black and Latinx students to engage in STEM yielded some powerful results. When 281 participants were asked to identify the factors that motivate STEM engagement in Black and Latinx students, 655 responses were generated. The major themes that emerged include obligation to Black/Latinx communities to break negative stigma and be different; future success because STEM is a prominent, progressive field; learning/discovery of STEM knowledge and real-life applicability; STEM passion/enjoyment; and solve problems to advance humanity.

The primary theme to emerge was obligation to the Black and Latinx communities to break negative perceptions and be different, reported by 122 (43%) of 281participants. This suggests that Black and Latinx students who are engaged in STEM have demonstrated resilience and have been able to positively combat the stereotypical perspectives and implicit bias that the literature states as a barrier to diversifying the STEM education to career pathway. It further suggests that in order to motivate Black and Latinx students that the STEM pathway must normalize STEM, using a culturally responsive approach. This is evident in participant comments below:

> *Because there is a lot of racism that affects them with their learning and can lead to think that they aren't smart and cause them to think they can't join these types of programs.*
>
> Middle School Student

> *It's more of an obligation and not necessarily to anyone around me, but to my ancestry. As I have gone through my education and gotten older the struggle of African Americans in America has grown more and more important to me as a person and I feel like the opportunities that I'm offered, no matter how good or bad they are, they are education…the more that I am offered these opportunities and I know I need to do well because the people before me did not have these opportunities and they paved the way to make sure I did have these opportunities…so when I do get the chance to learn something new I take it as chance to take advantage and appreciate what other people have done for me…when I get out into the world I know that what I'm doing was someone else's dream…I know that the work that I am doing and the knowledge that I have is because someone worked for me.*
>
> High School Student

> *A lot of the accomplishments and things that I see from my peers, that inspires and motivates me. In turn that kind of motivates me to just want to be successful for the sake of people who might look up to me so that I can be a role model to other people the same way that other people have been a role model to me so like at school. I'm part of the National Black Society of*

> *Engineers, so I can be a positive role model to all the underclassmen; especially going to a school where there's not a lot of Black people in general, especially in STEM. I feel like it's really important for me to be able to do well so you can go to that school and be in STEM and succeed.*
>
> College Student

> *His intrinsic motivators are most likely his love to solve critical problems quickly. In elementary school, his nickname was calculator, because he could solve problems faster than someone could insert into a calculator. In addition, he wants to represent Latinx doctors in STEM because when he was seven years old, he asked me in the hospital, "Where the Latinx doctors are at?" I remember replying that there are Latinx doctors, but there are few of them. You can become one when you grow up. After that, he made it his goal to want to become a doctor, for his want to represent the Latinx race.*
>
> Parent

> *His motivation is basically society always saying that African American males are not capable of. He feels like they are not put to the test. If there is a white student that is in the same class as them, that they are not expected to do as well as, and so he feels that he's motivated by hearing that you're not able and he says that I am able and that I am going to succeed. I think that goes for a lot of our youth. I think if they keep hearing, sometimes the more you hear that you can't do something, you know that you can do something. That's the motivation for a lot of our Black males right now.*
>
> Faculty/Staff

The secondary theme to emerge is future success, as STEM is a prominent, progressive field, reported by 115 (41%) of 281 respondents. This suggests that when Black and Latinx students understand the variety of STEM careers/potential earnings and that STEM innovation is a global focus with potential for industry growth, they are motivated to engage in STEM. Black and Latinx students should have exposure to an array of STEM careers and positions that utilize STEM skills as well as learn about global STEM opportunities. This is evident in the remarks below:

> *I think my biggest motivation is, well actually I have two motivations, one of them is I just really like learning so I try to be as well rounded of a student as I can; so even if I wasn't super interested in history, I would still try to be as involved in STEM as possible. Like now even as a STEM student, I try to learn about the arts and be well rounded but other than that I want to be an environmental engineer and do something with urban agriculture. Just the impact that I believe this can have on the world and the many problems in society it can cause, I just think that my main motivation is looking toward the future and looking for not like job prospects per say, even though there are a lot of jobs in environmental engineering more and more each day, but I think it's more like the change I can make in the world and that's what I'm looking towards.*
>
> High School Student

I think that my parents had to struggle to provide the things for our family; they never made their struggle clear to the kids because those aren't children issues. But I wanted to get into a field where I can get a good salary, immediately after college without having to do further school and engineering is one of the only fields like that. So I wanted to be able to provide for my family and things like that. I think of college as a pre-professional development opportunity…I think that whatever you learn in college should be applicable to some position to some job in the future and I think that you definitely get that in science and math education; where as in humanities you never really know where you're going to use that information in the future, so I wanted to pursue something that would have some sort of tangible benefit for me, some type of return on my investment.

College Student

The tertiary theme to emerge is learning/discovery of STEM knowledge, reported by 115 (41%) of 281 participants. This suggests that Black and Latinx students are intrigued by STEM concepts and interested in being STEM literate. There is a need for Black and Latinx students to be exposed to consistent STEM teaching and learning that is engaging and inquiry-based to enhance motivation. This is evident in their responses below:

I do want to find out as much as I can…but I fell into STEM education. There's something unique about it that is not really relevant or apparent in any other aspects of learning…there's this knowledge that no matter how much you know, you will never know all of it so being part of STEM education drives me to know…throughout my years, I'll never get bored…I'll always have more things to find out…there's always my posterity to do…its inspiring to know that I'll be finding new things possibly, but there is always more to know.

High School Student

One of the things that I always personally admired was education and like knowledge in general and seeing people have access. I, myself, have always more or less gone towards STEM or gravitated towards it because I want to have it myself and have always liked being able to go and try new things and be able to attain new knowledge; especially something I focus on because for some reason I always like found plants very intriguing so I always wanted to learn and study about them, so because I wanted to learn about it, I sought what I needed to understand it.

College Student

My son has been passionate about math and science since he was a toddler. He's always been interested in the "why" and "how" something works. As a toddler, it wasn't enough for him to build the provided track layouts for his train set, he wanted to create his own and design layouts with hills and curves, understanding conceptually that hills had to be the right height so that

> *the train can go over it and not get stuck and curves couldn't be too steep or else it fell off the track. Not only did he enjoy learning how something worked, he liked to explain it to others, which deepened his understanding even further. His sense of accomplishment and pride has always been visible in his face and demeanor when concepts "click".*
>
> Parent

> *Their intrinsic motivation comes from their confidence, knowing and learning and wanting to learn more, but it is also when they are successful. When they are successful, then they want to do more. Examples of that would be students at IMSA go up against a teacher that they feel that they never could communicate with or that teacher will never listen or help me. Once they realized that the teacher is there for them, and willing to help and guide them, the teacher is there to work with them or sometimes banter with then; then I believe that is when the tables turn a little bit. Confidence is built and they are finding success. It's also that sometimes it is fun. Sometimes I see the students doing different experiments with different peers, which look like they are having a lot of fun. I think that's where it comes from. IMSA students study STEM and their intrinsic motivation is also the fact that they know they could do and that it is something else out there. There is something beyond what is in their community. For others, it is there because they want to be better or learn.*
>
> Faculty/staff

The next theme that arose is STEM passion/enjoyment, reported by 97 (35%) of 281 participants. Some Black and Latinx students have a natural inclination towards STEM and are genuinely interested. Although, it may be hard to develop this in students, it is important to expose students to STEM and nurture their STEM development to enhance motivation, as evident in the comments below:

> *Now, I'm engaged in STEM because I love it so much, it's very entertaining and interesting to me…but, I have to credit my parents for my engagement and involvement in STEM. As far as I've been told and can remember when I was younger my parents would put me in front of the computer and have me doing math problems before I was even in preschool and things like that. So I had an early interest for STEM and throughout the years it's become bigger and bigger because I have a natural infinity for it, I toyed more and more with it and I help other people with it and so it's just always been a part of me.*
>
> High School Student

> *It's not some sort of higher calling or money. It's always been passion for STEM…growing up I never knew what I wanted to do until I discovered my passion for STEM…the fact that I wanted to study STEM and my number one college choice is very STEM heavy, Cal tech, and if I get in, I will be studying STEM very thoroughly and the reason I want to do that is because I like to learn about STEM. I find it fun, I think the concepts are interesting and what*

I do with STEM… there is a good possibility that I will advance the human condition…but for me and motivation to do STEM is because I am very interested in the subject matter.

High School Student

Well I think when he was younger, when he was about 2 years old and he was counting real high and I was amazed he was counting to like 200 and 300 and he recognized patterns with numbers right away and when I saw that we just kept going with it. He enjoyed that he was so good at it so he wanted to keep going with it and find out how far he could go with it. He would get books on his own, he would try to solve problems in different ways, other than what he was being taught in school … and he just liked being able to do this. He noticed right away that other kids were not able to do it; but what I think made it intrinsic in him, is that he knew he was good at it.

Parent

The fifth theme to emerge is solve problems to advance humanity, reported by 69 (25%) of 281 participants. This suggests that to motivate Black and Latinx students to engage in STEM, they need to work on solving societal and global issues, especially those that culturally/personally relate to them. It also suggests that Black and Latinx students need to understand the complexity of the problems, such as contributing social, environmental and economic factors. Below are participant remarks that suggest solving problems motivates STEM engagement in Black and Latinx students:

I think the gap exists because humanity is tearing us apart. Something that would motivate me to engage in STEM is us Blacks and Latinos working together to make the world a better and more positive place and for us not to think we can't follow our dreams.

Middle School Student

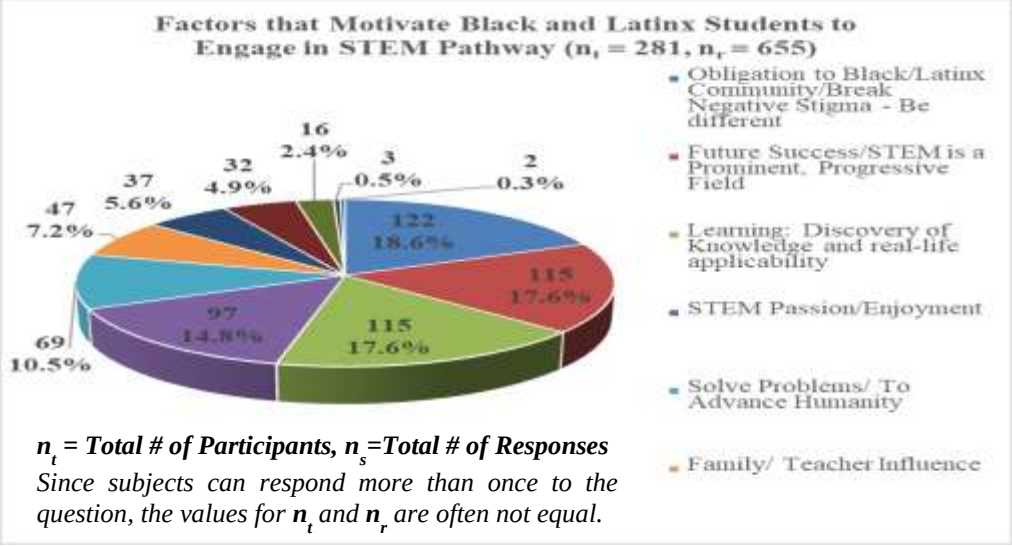
When I was in middle school, my motivation in STEM and I loved math, started off with a problem I could not solve and working my way through it and feeling the success of. I problem solved and I used my abilities to solve something to get an answer correct. I think that was my motivation, to get a correct answer…and now I like at my SIR [student inquiry and research]. I was doing rounds and there was one patient who literally the day before, his colon was in bad shape, and they removed it and he was on the verge of death and it changed from death to life in literally a matter of hours and I just find that fascinating and that drives me to go further, to push myself because I know that one life saved…if I become a doctor…one life saved is honestly, it's like the top. I don't know how to describe it…I've strayed away from the competition since I've been at IMSA…so I just want to prove to myself that I'm doing something useful worthwhile.

High School Student

> *It's always going to be a need for programmers and people to push the human condition forward and frankly as we grow forward, 10 years, 50 years from now; technology will be the only way to save ourselves as a culture because there are so many problems and not to sound, to have such a downer, but there are so many problems' and technology is going to be a way to fix a lot of those problems and not just technical problems; but problems with democracy, problems with communication, problems with just meeting people in fact science and technology is the way to solve a lot of those. – College Student*
>
> *It started back in elementary, I would say puzzles, any kind of puzzle, anything that gets his mind going to solve something, he's always been gravitated to and when it comes to helping others rather it be through tutoring. He's always been one to volunteer for those types of things and I think he gets a lot of joy out of helping others and again solving mathematical or science types of things, equations, problems. That gets him going and part of it is this new range, he's very much into the internet as well as these textbox games, I think intrigues him; not just the game, but the ability to see how it works.*
>
> Parent

Other themes to emerge include family/teacher influence, challenge/ competitive nature of STEM, money, self-motivation, not good at math and leadership. There are both intrinsic and extrinsic factors that motivate Black and Latinx students to engage in STEM education and careers. The figure below shows the frequency of responses regarding the factors that motivate Black and Latinx students to engage in STEM, with a total of 655 responses:

Figure 2. STEM Motivation Factors



n_t = Total # of Participants, n_s=Total # of Responses
Since subjects can respond more than once to the question, the values for ***n_t*** *and* ***n_r*** *are often not equal.*

This research has built upon a preliminary study, Yes, STEM is for all: Diverse Perspectives on Black and Latinx STEM Motivation; adding the perspectives of middle school students, college students and geographic-based perspectives (i.e. high school students from the State of Ohio and Washington

D.C.), 118 additional participants (Coleman et al., 2018). This previous qualitative study, consisting of data from focus groups with 85 students and interviews with 51 parents and 27 faculty/staff, put forth a 5-step approach to STEM motivation that was inclusive of early STEM exposure, IMSA as a model, Historical and Current News/Issues Discussion, Personalized Assessment and Evaluation, and STEM Leadership Development (Coleman et al., 2018).

Three of the steps, early STEM exposure, personalized assessment and evaluation and STEM leadership development were built upon, but remained consistent with the data. Two of the steps, IMSA as a model and historical and current news/issues discussion were collapsed into modified steps, culturally responsive STEM curriculum and conversations on race, and further developed to include additional data and demonstrate emerging trends. Being inclusive of the additional data that was collected on STEM motivation, the following 5-step approach to motivating Black and Latinx students to engage in STEM has been updated:

Table 2. A 5-Step Approach to STEM Motivation for Black and Latinx Students

1. Early STEM Exposure	▪ PreK-16 STEM immersion, in school and Saturday/Summer enrichment programs. ▪ Exposure to an array of STEM careers and careers that desire STEM skills, along with potential financial earnings. ▪ Bilingual STEM Advocacy Education and STEM Skill Development for parents.
2. Culturally Responsive STEM Curriculum	▪ Engage Black and Latinx students in becoming STEM literate and STEM thinking that is inquiry driven and rooted in solving problems that are of interest to them, their race and the world. ▪ Normalize Black and Latinx students being engaged in STEM education and careers through addressing implicit bias with teachers and stereotype threat with students, as well as provide visions of Black and Latinx people engage(d) in STEM; moving the students towards a growth mindset. ▪ Teaching and Learning should occur beyond a Westernized lens.
3. Conversations on Race	As indicated as a factor of motivation, Black and Latinx students are motivated to engage in STEM because of their obligation to the their respective communities to break negative stigmas and be role models; thus there needs to be space to discuss race through a historical, social and environmental lens, including this intersect between race and STEM.
4. Personalized Assessment and Evaluation	▪ Regular assessment of Black and Latinx students utilizing an asset-based approach, rather than a deficit-based approach. ▪ Growth-mindset coaching with Black and Latinx Students to help them develop confidence and the vision of themselves being engaged in STEM. ▪ Intentional relationship development between educators and students in order to identify potential STEM talent/passion from a relational perspective, as well as potentially have an understanding of what may be impeding STEM motivation.
5. STEM Leadership Development	"The STEM areas in which the Black and Latinx Students have demonstrated strength need to be complemented with a STEM lesson led by the student that has a problem-solving component. Opportunities to lead STEM research projects that advance humanity should be provided. Leadership opportunities outside of STEM are also important for leadership development and skill application. This will allow them to develop leadership skills needed to be successful STEM leaders in a global world" (Coleman et al., 2018).

Diversifying STEM Think Tank

Participants of the Diversifying STEM Think Tanks were asked to discuss why there was a racial STEM divide and strategies to diversify the STEM Education to Career Pathway. Eight major issues emerged; vision gap, opportunity gap, cultural perception gap, STEM education gap, generational gap, economic gap, identification gap, and STEM professional to educator gap. Although some of these issues have been discussed in professional literature, the main finding of this study is that these problems must be examined and resolved collectively and not in isolation, for the highest likelihood to diversify the STEM education to career pathway. In addition, it was agreed that there must be a policy-driven, collaborative STEM initiative between STEM educators, STEM professionals and the community. There was also a call to examine STEM teacher preparation issues, especially the decreasing number actually entering the field, along with implicit bias and inadequate cultural competence. Below are the defined problems along with solutions that emerged from the Diversifying STEM Think Tanks:

Table 3. Diversifying STEM Think Tank Results

Gap	Definition	Solution
Vision Gap	Lack of vision to enter a STEM field due to racial isolation in STEM courses/programs. Lack of Black and Latinx role models/mentors, stereotype of STEM "not being cool" so students suffer from the "cool pose" and a feeling of not belonging.	• Normalize STEM education, majors and careers as attainable and desirable for Black and Latinx students. • Engage Black and Latinx STEM professionals in STEM education and programming.
Opportunity Gap	Lack of both STEM access and exposure.	• Engage students in STEM pathway by providing educational, research and internship opportunities in local, national and global space for PreK – 16, Black and Latinx students at no to low cost.
Cultural Perception Gap	Resulting from systemic bias, negative stigma/misperception of Black and Latinx students related to their overall intelligence and STEM potential. Resulting from stereotype threat, Black/Latinx students hide their intelligence and STEM potential.	• Implicit bias and culturally responsive pedagogy training, with emphasis on STEM equity for educators, administrators and policy-makers. • Confront stereotype threat; create a public presence that visually displays diverse groups of STEM educators/professionals, specifically Black and Latinx.
STEM Education Gap	Lack of quality STEM education/teacher preparedness and interest. Lack of practical application in STEM teaching and learning	• STEM skill development experience for educators. • Professional development for educators on development of real-life, culturally responsive STEM curriculum.

		• Course on diversifying STEM fields with and intricate look at STEM inequity for school administrators and teacher certification programs.
Generational Gap	Parents lack of STEM skills and knowledge, as well as do not understand the significance of entering STEM, which results in a lack of STEM advocacy for their student. Linguistic and STEM literacy barriers.	• Host bilingual parent education sessions on how to advocate for their student in STEM engagement, resulting in a more STEM literate parents. • Provide professional learning opportunities in which parents develop STEM skills for possible career enhancement or change.
Economic Gap	Schools System Funding Issues/Funding for Families	• Create equity in school funding for STEM programs. • Inform families of free and low-cost STEM resources for families.
Identification Gap	Lack of STEM talent identification protocol or awareness education by teachers and/or parents - No training for teachers.	• Develop a culturally responsive STEM talent identity protocol, based on research and then provide professional learning that trains STEM educators and parents to implement.
STEM Professional to Educator Gap	Discouragement of STEM Professionals to become STEM Educators – it is challenging for STEM Professionals to become teachers due to certification guidelines.	• Collaborate with colleges and universities to develop an expedited teacher certification process for STEM Educators that takes into account their level of experience.

Discussion

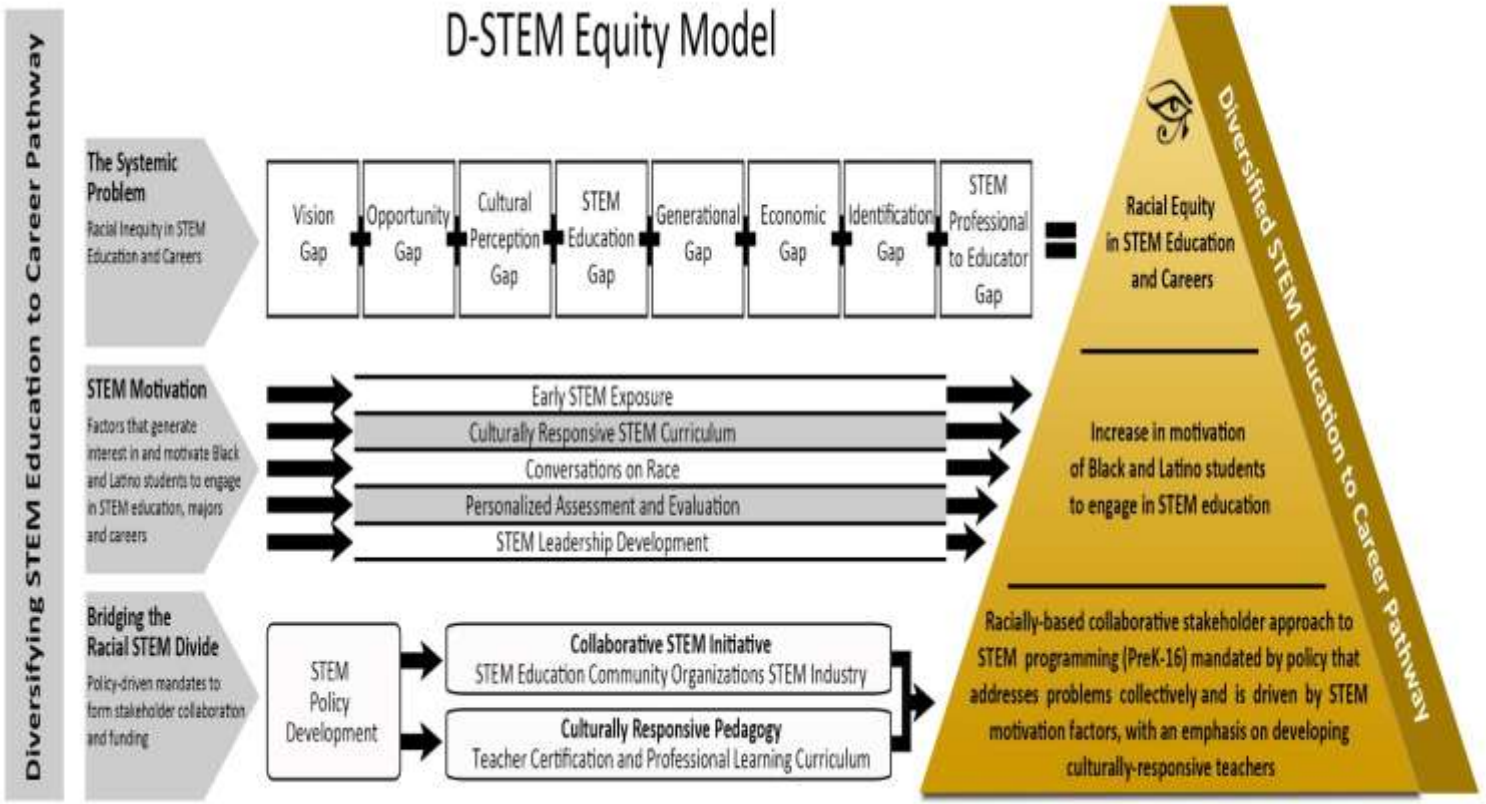
"There is little prior research at the national level on how racial/ethnic differences in preparation contribute to inequity in STEM fields"; thus, the D-STEM Equity Model is a proposed national-based approach to diversifying the STEM education to career pathway with global scalability (Riegle-Crumb & King, 2010). It provides a comprehensive perspective of the problems related to racially-based STEM inequities, is rooted in factors that motivate STEM engagement in Black and Latinx students and emboldens a culturally-responsive collaborative strategy to address the racially-based STEM inequity holistically. The Diversifying STEM Equity Model (D-STEM Equity Model), connects two studies; one that focused on factors that motivate Black and Latinx students to engage in STEM, the other focused on identifying and addressing issues related to the racial STEM divide; with the goal of informing diversifying the STEM education to career pathway.

There are eight major problems contributing to racial inequity in STEM education and careers, specifically as it relates to Black and Latinx student STEM engagement; including vision, opportunity, cultural perception, STEM education, generational, economic, identification, and STEM professional to educator gaps.

Using the strategies previously proposed in *Table 3*, the identified problems should be addressed holistically and not in isolation, which will lead to improved racial equity and assist in diversifying the STEM education to career pathway. There are also five significant factors that motivate Black and Latinx Students to engage in STEM that include early STEM exposure, culturally responsive STEM curriculum, conversations on race, personalized assessment and evaluation, and STEM leadership development, previously explained in *Table 2*. If students engage in one or more of these motivation pathways, it will lead to an increased interest and engagement in STEM, which too will assist in diversifying the STEM education to career pathway. Considering the intersection of motivation factors and the identified problems; early STEM exposure addresses the vision, opportunity, generational and STEM education gaps, culturally responsive STEM curriculum/ conversations on race/STEM leadership addresses the vision and cultural perception gaps and, personalized assessment and evaluation addresses the STEM education and identification gaps.

To address the additional economic and STEM professional to educator gaps and truly bridge the racial STEM divide, policy must be implemented that provides funding for a collaborative PreK-16 STEM initiative and culturally responsive training for STEM educators and those in preparation, as well as STEM professionals who want to enter academe. "Diversifying STEM policies" need to be developed that mandate funding for racially-based collaborative STEM initiatives to be implemented, that work towards achieving equity by addressing the identified problems collectively and integrating factors of Black and Latinx student STEM motivation into STEM programming; as well as encourages culturally responsive training for state/national teacher certification and current STEM educators. This will lead to a diversified STEM education to career pathway, as displayed in the D-STEM Equity Model below:

Figure 3. Diversifying STEM Equity Model



Conclusions

An intricate examination of the racial STEM divide and strategies to address that gap along with a racially-based STEM motivation approach were presented throughout this paper. Connecting this data led to the development of the D-STEM Equity Model as an approach to diversify the STEM Education to Career Pathway model, which can be applied on local, state, regional or national levels. Governmental agencies, educational institutions, STEM industry and community organizations are encouraged to collaboratively adopt this model to build upon the research by testing its' effectiveness, while increasing Black and Latinx persons' engagement in STEM education and careers.

Considering that those underrepresented in STEM extend beyond race in the United States, the D-STEM Equity Model can be applied on a global scale. Utilizing the research methodology approach discussed in this study, additional research must be conducted on the underrepresented group in order to gain a better understanding of the problem, strategies to address the problem and motivation of those from the underrepresented group who are engaged in STEM. The following steps should be taken to scale the D-STEM Equity Model for global application:

1. Identify groups who are underrepresented in STEM and host "Diversifying STEM Think Tanks" to gain a better perspective as to why STEM inequities exist within the respective group(s) and strategies to address.
2. Hold focus groups with members of identified group who are engaged in STEM to understand what motivates them to engage in STEM.
3. Identify stakeholders who will value from diversifying STEM and policy-makers who are STEM advocates to move toward a collaborative STEM initiative.
4. Identify other barriers to diversifying STEM that exists for the respective group(s).
5. Based on the data collected, modify the language in the D-STEM equity model to include identified problem, motivation factors, bridging component, which include stakeholders and additional barriers.

Application of the evidence-based D-STEM Equity Model can definitely assist in addressing the global demand for STEM professionals and those who possess STEM skills. It can also assist the United States in bridging the racial STEM divide, which can indirectly influence unemployment, address issues of poverty and impact economic growth in Black and Latinx communities. This is STEM Innovation!

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