

## **Renewed Hope: Utilizing Freirean Pedagogies to Enhance Multicultural STEM Classrooms**

### **Cassandra Puletapuai, Colorado State University**

Cassandra Puletapuai is a construction management graduate research assistant, graduate teaching assistant, a doctoral student at Colorado School University in the School of Education in Education, Equity, and Transformation focusing on Construction Management. Her research interests include sociocultural and participatory action research practices that connect both the individual's and industry's vision for beneficial and tangible outcomes and increasing multicultural supportability in construction/engineering professional and academic spaces.

### **Dr. Daniel Birmingham, Colorado State University**

Associate Professor of STEM Education in the School of Education and Colorado State University. Dr. Birmingham's research examines potential avenues to bridge community and educational experiences in order to alter modes of participation in STEM and support transformative learning for students from traditionally marginalized communities. A central aspect of his research is focused on the design of collaborative forms of qualitative research necessary for expanding dialog on the enduring challenges we face in the areas of educational equity and opportunity in STEM education.

# **Renewed hope: Utilizing Freirean pedagogies to enhance multicultural STEM classrooms**

## **Abstract**

The STEM field for the underrepresented is analogous to the "leaky pipeline" metaphor, which describes the mass exodus of minority students over the course of time [1]. Nationally, the attrition rate of STEM majors for underrepresented students failing to complete their degree hovers at 53 percent [2]. Students of Color have endured many challenges in the STEM classroom, resembling isolation [2], stereotype threats, racial microaggressions, lack of confidence, diminished sense of belonging, and other hurdles as a result of race or gender [1]. These factors contribute to the exclusivity in the STEM classroom [2]. Many underrepresented students regard professors of Color as evidence of success and role models [3]. Often, professors of Color connect with students of Color because of shared experiences [3]. However, the pool of diverse faculty remains limited. The National Center for Education Statistics (2022) reported the racial makeup of 1.5 million postsecondary faculty as Asian/Pacific Islander males at 7 percent, Asian/Pacific Islander females at 5 percent, Black females at 4 percent, Black males, Hispanic males, and Hispanic females each at 3 percent, American Indian/Alaska Native individuals, and individuals of two or more races at 1 percent [4]. How can we encourage and advocate for students of Color in STEM and create an inclusive classroom while representation remains sparse with faculty identity alignment? This paper highlights the challenges faced by students of Color in STEM. We synthesize Freirean pedagogies to offer strategies for higher education faculty to employ in their classrooms to overcome challenges, retain, and support students of Color in STEM fields similar to engineering. More importantly, we aim to provide approaches for enhancing the creation of an inclusive learning environment. Though Freirean pedagogies are not typical in traditional engineering education capacities, its perspectives use student-centered experiences in the learning process, promoting all-embracing spaces. In an inclusive classroom, all voices, regardless of background, have an equitable opportunity to thrive, add, and craft to the science community dialogue [2].

## **Keywords**

STEM Students of Color, Freire, Hope, Critical Consciousness, Multicultural/Transformative Education

## **Who participates in STEM**

For underrepresented individuals, the journey into and through STEM appears arduous, and their promising aspirations often wistfully dissipate into a pipe dream. Why must the path forward become a Sisyphean task for students of Color in STEM? Academics often strive to achieve a mission and vision of multicultural competency in their learning communities with well-intentioned initiatives and developments; however, many fall short. An intercultural and multicultural review unveiled efforts made toward multicultural competency in STEM classrooms germinated from the best ambitions but proved hollow [5]. These intentions often lacked the depth of multicultural sensitivity as the efforts and outlooks suffer from simplicity [5].

Previous research literature germane to students of Color's university experiences in STEM stipulates vexatious challenges that impede full participation and a sense of belonging [6]. These include but are not limited to; a negative campus climate shaped by microaggressive occurrences [7]; dominant culture reinforcement in STEM classrooms that serve to exclude students of Color [2], deficient social networking for career advancement opportunities [1], absence in the perception of the community [6], and racist stereotypes, tokenism, cultural confinement, mistaken cultural portrayals [8]. As evidenced above, students of Color experience a litany of challenges all of which contribute to the floundering presence in STEM.

The results of these systemic issues in STEM learning environments have far-reaching negative ramifications for both current and future experiences of students of Color. For example, in 2018, the National Center for Science and Engineering Statistics (NCSES) reported those underrepresented in STEM comprised just 24% of science and engineering (S&E) of total bachelor's degrees, 22.1% of all master's degrees, and 13.6% of overall S&E degrees. In contrast, about two-thirds of the employed scientists and engineers identify racially as White [9]. In 2019, NCSES noted out of all the science, engineering, and health (SEH) doctoral degrees, women held 38.5%, which increased from 1999's numbers of 26.4%. Underrepresented occupied 8.9% of SEH doctoral degrees [9]. Women of Color were not highlighted in these SEH doctoral populations.

Professors of Color serve as a tremendous support system, especially in predominantly White institutions (PWIs). Brimming with relatable experience, professors of Color may associate with similar hurdles faced by students of Color in profound ways [3]. Educators of Color resemble the height of achievement [3] and may help students of Color in the capacity of role models and construct the possibility for students to see themselves in the same major. Previous studies demonstrate the strong connection between faculty relationships and student success [3]. The diversity of faculty plays a substantial role in enticing and retaining other multicultural staff and students, enhancing student experiences in the university climate, and promoting social justice efforts [10]. However, the presence of faculty of Color in STEM fields remains incredibly low with the racial makeup of 1.5 million postsecondary faculty as Asian/Pacific Islander males at 7 percent, Asian/Pacific Islander females at 5 percent, Black females at 4 percent, Black males, Hispanic males, and Hispanic females each at 3 percent, American Indian/Alaska Native individuals, and individuals of two or more races at 1 percent [9]. Thus, students of Color face limitations in drawing beneficial support from this narrow group of educators, especially in the majority of settings where faculty of Color remain small-scale.

In this paper, we argue that the current culture(s) of STEM learning environments must be addressed now if the field is going to support participation from more students, and faculty, of Color. We seek to address the urgency and necessity for all STEM educators to ingrain multicultural competency tactics to help craft a STEM world that develops a multicultural and successful community of practice. In particular, we point to the work of educational theorist Paulo Freire and use his ideologies of hope and critical consciousness as frameworks to help shift the culture of STEM classrooms to be more inclusive and welcoming to students of Color.

In what follows, we further highlight the barriers students of Color encounter when navigating STEM education and careers. Next, we delve into two of Paulo Freire's frameworks,

*critical consciousness*, and *hope*, and connect these frameworks with the aim of inclusive STEM learning environments. We end by discussing the implications and next steps of this work.

### **Barriers to Full Participation in STEM for Students of Color**

To no surprise, students of Color and predominately White higher education institutions (PWIs) interact with noxious turbulence as empirically described in the extensive history of students of Color research in higher learning institutions [8]. Previous research detailed the student of Color experiences as contentious and destructive which impede a conducive learning atmosphere and feed into the immense student of Color attrition rates [8]. Studies on racial climates at PWIs suggested the issues were deep-seated and influential in perpetuating the adverse encounters for students of Color and persuading PWIs' values. To much chagrin, these conditions preserve the lack of multicultural policies and substantive practices which saturate campus culture and translate into the classroom [8]. Classroom curriculum has little to no priority in integrating cultural representation based on students of Color experiences in prior studies [8]. Though academic institutions attempt to adapt social justice concepts as a guide, many educators struggle in preparation for operationalizing the themes of social justice and inclusivity into the classroom which results in the continuance of inequitable students of Color experiences.

One of the many ways these barriers manifest is through racial microaggressions defined as “subtle, everyday interactions, and climates based on racial stereotypes that challenge underrepresented students’ sense of belonging” [11, p. 1612]. Prolonged exposure to racial microaggressions takes quite a toll on students of Color. The adverse health consequences include poor self-esteem, physical health issues, and emotional anguish [8] shrouded in high levels of stress. Not to mention, microaggressions impact a student of Color’s academic performance by discouraging participation and minimizing engagement [8]. These microaggressions often occur in interactions with professors and peers within the learning environment and often result in students of Color feeling unwelcome, invisible, or misunderstood.

The barriers to full participation can be even more acute when students hold more than one identity that is underrepresented in STEM. For example, the tenuous participation of women of Color in STEM bespeaks the challenges confronted and uniquely to their intersectional identity. Women of Color in STEM may undergo an excluding STEM environment, misunderstood or indifferent toward WOC experiences, lack of academic rigor assumptions [12], sexism, stereotype threats, racial microaggression, societal stereotypes [1], isolation, non-existent sense of belonging, uncertainty, insufficient faculty support, and social and cultural conflicts [13].

It is clear that if we are to transform higher education to better support students of Color, change is needed. In order to better equip faculty to understand the experiences and empower students of Color in STEM, we turn to the pedagogical theories and actions of Paulo Freire. We argue that the adoption and inclusion of these theoretical approaches would provide a more inclusive environment for students of Color in STEM that provides opportunities for these students to participate fully and be recognized for their contributions.

## Looking to Paulo Freire for Answers

When conjuring the concepts of transformative and humanizing education leading toward more inclusive and multicultural learning environments [14], Paulo Freire materializes. Paulo Freire was a Brazilian educator and philosopher whose critical pedagogies envelope compassion, hope, love, and the heartfelt spirit of social justice. Freire's work focused on empowering the poor and oppressed in Brazil who were not provided educational opportunities resulting in unequal distribution of power and social capital. Freire's "students" were not allowed to participate fully in both education and society due to their position, class, and race. His ideas translate and help us understand the experiences of students of Color and the disparity they come up against in their STEM communities which relate directly to issues of power and access. Furthermore, Freire draws attention to the need for critical consciousness to embolden the liberation from the restrictive curriculum or the "banking model" of education where faculty make knowledge deposits in students resulting in positioning students as passive receptors of knowledge [15]. When students are positioned as passive, they are often left silent and powerless to impact the learning environment they find themselves. Given the complexity of a multicultural classroom, Freire's philosophies avoid the rigidness of 'best practice' to allow for fluidity through adaptation, recreation, and the inclusion of student experience in the learning process [14].

Educators struggle with constructing productive classroom conversations regarding multicultural concerns in anticipation of losing control, seeming multiculturally incompetent, or favoring others [8]. These circumstances result in professors adopting the practice of avoidance and diversion as strategies to counteract classroom conflicts [8]. As experts in their respective subject matter, educators hold extraordinary power over students. A double-pronged power that may indoctrinate and control or liberate [8]. It is at this optimal juncture that the professor may choose to incorporate alternative Freirean approaches. Freirean pedagogies gently excavate a pathway toward a dialogic classroom setting that encourages open and impartial communication between instructor and student as well as student and student. Freire believed that dialogue was not a teaching technique, but instead "an indispensable component of the process of both learning and knowing" [15, p.17]. It is through dialogue that we understand the social, cultural, and individual aspects of how we come to knowledge, how we choose to participate in learning, and what each other draws upon to make sense of the world they find themselves in.

Genuine dialogue erodes without the shoring of trust. Bridging trust involves an authentic interest in hearing the triumphs and tribulations of students' journeys. A paradoxical approach to the monologue (solely from the professor) in the traditional classroom setting [14]. It is when educators attempt approaches that comprehend themselves and empathize with students, the instructor finds themselves in a place to shape multicultural and embracing spaces [2]. Multicultural education concepts firmly propagate systems that encourage and sustain teaching and learning in all-encompassing environments [2]. Furthermore, these models effervesce inclusive instruction, positive campus climate, and multifaceted curriculum development [2]. Previous literature concluded the five dimensions of multicultural education included "the knowledge construction process, content integration, prejudice reduction, equitable pedagogies, and empowering school culture" [2, p.172]. While incorporating a Freirean dialogic process into classrooms where power and authority are shared between students and teachers brings us closer

to realizing these multicultural dimensions, we are also urging faculty to bring a critical consciousness and a pedagogy of hope into the classroom to better achieve this goal. Below we outline these approaches and their relationship to these critical dimensions of multicultural education.

### **Growing a Critical Conscience**

One pathway toward a multicultural and inclusive classroom climate comes through what Freire [15] describes as conscientizacao or critical consciousness. Freire defines critical consciousness as “the process of developing knowledge and “personal concern” for social justice leading to action” [5, p. 276]. Through critical awareness, individuals expand their ability to rebuff the instruction of others and progress toward dissembling the colonnades of oppression. Critical consciousness seeks to share power with those who are socially, historically, and politically oppressed in ways that they not only recognize but challenge unjust systems.

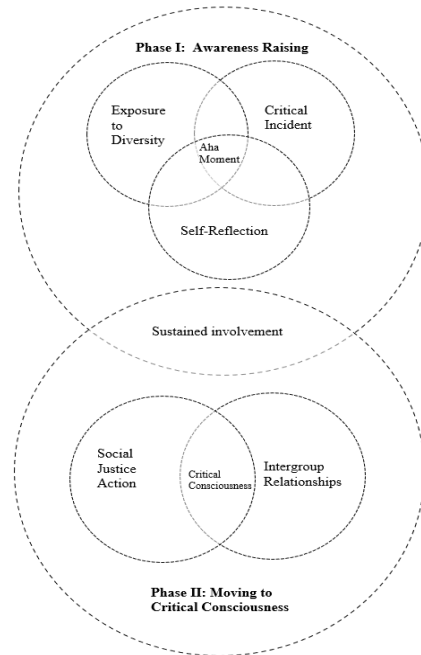
Developing critical consciousness cannot be based solely on training or competence [5]. As Freire argues, “to affirm that men and women are persons and as persons should be free, and yet to do nothing tangible to make this affirmation as reality, is a farce” [15, p. 50]. Thus, altering the conditions students of Color find in STEM requires reflection, engagement, and action toward social justice goals from those with power. By establishing a critical consciousness as the foundation, allies can effectively work toward multicultural competency. These efforts would include dimensions of multicultural education such as better understanding and critiquing the knowledge construction process through sharing power and authority. In addition, these efforts when engaged in reflectively can work toward uncovering explicit/implicit bias in the classroom and challenging prejudice that many students of Color experience. In partnership with students of Color, all instructors play a vital role beyond the traditional context of teaching and in co-creating empowering school/classroom climates for their students. In this way, instructors can work toward the goals of maintaining and retaining multicultural students and are empowered with the ability to disrupt the challenges met by students of Color [8].

Landreman’s et al. [5] critical consciousness model in Figure 1 echoes Freire’s ideologies but moves from theory to action in two distinct phases. In phase one, four themes emerge in raising awareness critically: (a) “exposure to diversity”, (b) “critical incidents”, (c) “self-reflection”, and the (d) “aha moment” [5, p. 281]. Our exposure geographically or interactions with people of diverse communities serves as the initial stage of raising awareness. The convergence of multifaceted dimensions of cultural identity prompts the realization of social stratifications encircling race and gender, bias, and stereotypes [5]. Not including an invitation to reflect upon our position and how it is situated in society, culture, communities, and more in a socially stratified system. Critical incidents comprise of experiences, powerful events, and interactions that kindle self-reflection, interpretation of meaning, and continuation of multicultural engagement. These incidents help individuals contribute to understanding their privileges, biases, and prejudices. The self-reflection stage derives sense from these situations that increase awareness [5].

With self-reflection compassionately fixed to our consciousness, it may guide "purposeful reflection" and intrinsic to "transformational education" [16, p. 95]. Purposeful reflection functions as a pivoting point in continuous learning and teaching by presenting

opportunities for open dialogue sessions. A space where students may reflect on thoughts and ideas, share lived experiences, and enhance their identity. Instructors may integrate purposeful reflection or dialogue opportunities through meetings with students and other related organizations to focus on multicultural students' needs. By establishing sessions for conversational opportunities, we contribute to sharing and building community-based and legitimate classroom-based knowledge, which reinforces learning settings, maintains reflection on educational content, and grants a student-centered structure. [16]. The convergence of exposure to diversity, critical incidents, and self-reflection leads to the aha moment. Individuals comprehend the magnitude of these events and circumstances and can expand on social injustice issues. Additionally, individuals possess a deeper awareness of their position in the social hierarchy. More importantly, the newly astomatous groundwork plays a role in experiences, and understanding continues to build in a cyclical sense, harmoniously moving among each theme and feeding into phase two [5].

In phase two, critical consciousness (Figure 1) mobilizes through the themes of (a) "sustained involvement", (b) "engagement in social justice action and coalition building", and (c) "intergroup relationship building" [5, p. 288-289]. Moving into the second phase and toward critical consciousness requires repeated involvement versus one-and-done. The aha moment acts as the jumping-off point pivoting into the second phase. However, the constant themes of the first phase catalyze the transition into the second phase and are necessary to propel individuals into critical consciousness. Individuals develop and craft a lens that frequently navigates and examines social justice's inner workings and connections. The second theme involves engaging in coalition building and social action. Associating with organizations centered on social justice further supports the awareness of critical issues. The gathering of socially justice-orientated minds initiates a space for thoughts, objectives, and conversations, inspiring an all-embracing future. Individuals become empowered to address social justice issues in neoteric ways. The next theme deals with building intergroup relationships, particularly with various backgrounds. In bridging relationships with multicultural identities, they act as influencers, support, educators, and constructive challengers in critical consciousness development. Establishing profound multicultural relationships forges a derring-do partnership of trust and commitment to each other. An opportunity for honest and open dialogue arises in hopes of architecting meaningful critical consciousness [5].



**Figure 1. Critical Consciousness Development: Phase I and Phase II. Adapted from [5].**

Landreman’s et al. [5] conception of Freire’s critical consciousness helps instructors and students work together toward the dimensions of multicultural education. This includes engaging in equitable practices that share power, legitimizing experience that sits outside of what is traditionally legitimate in STEM classrooms and working toward a dialogic process between all members of the classroom. These practices lead to challenging linear pathways toward the construction of knowledge and hold the potential to make bias (both explicit and illicit) visible as students and instructors work together to create inclusive classrooms.

### **Facilitators of Hope**

Ontology describes the “nature of social reality” including examining who defines that reality and how it is defined [17, p. 92]. “In practice, ontology means a hierarchy of concepts with a set of properties and relations that represent a domain” [18, p. 5301-5302]. In education, the application of ontology meets success as the instructor permits the development of a learning domain by describing all included concepts, the relations among concepts, and the characteristics and circumstances that occur [18] or as Smith commented, “the science of what is” [18, p. 5302]. Ontologies allow for a transparent and definite approach to systematic knowledge, and yet often exclude the realities of many in favor of the reality of those in power.

The exclusion in STEM education often is most harmful to students of Color where their realities are positioned as invisible or undesirable. In the context of students of Color in STEM, racial microaggressions yield cognitive-emotional factors similar to hopelessness [19]. Freire [15] warns us of the danger of hopelessness and what distinguishes it from the properties of hope;



Hopelessness is a form of silence, of denying the world and fleeing from it. The dehumanization resulting from an unjust order is not cause for despair but for hope, leading to the incessant pursuit of the humanity denied by injustice. Hope, however, does not consist of crossing one's arms and waiting. As long as I fight, I am moved by hope: and if I fight with hope, then I can't wait [15, p. 72-73].

As hopelessness insidiously ingrains and petrifies the STEM experience of students of Color, we see the relevance and necessity for instructors to incorporate Freire's pedagogy of hope in STEM classrooms. A feeling of trust or the belief or desire for something to happen describes hope. Hope deals with pernicious situations [20] similar to the challenges faced by students of Color in STEM and requires action with urgency.

Freire [21] refers to hope as the catalyst for education and the epicenter of educational ontology(s). Hope and education dwell in the incompleteness of an individual and the awareness of this incompleteness. Hope and education stem from the same ontological foundations in which we share realities instead of ceding to the most dominant notion. The intention of education acts as a long-lasting guide to the never-ending search for hope and acts as the illustrious backdrop for inducing hope and guidance. Educators should focus their efforts on sustaining and cultivating complex intricate hope as a simplistic manner would promote instability, and videlicet, among students [22].

Hope positively influences individuals to retain better physical and mental health and performance in the workplace, athletic and academic environments than those without hope. Hope represents "a positive sense of self and their purpose in life even in the most dehumanizing of circumstances" [16] and "a base for envisioning a better world" [16, p.89]. Hope emanates from goal-orientated thinking and tethers emotions to it [16], as goals determine one's feelings [16]. Individuals surmounting a challenge have a goal in place. Achieving objectives infiltrate hope across all spectrums of an individual's life. Hope trends upward when an individual obtains the opportunity to pursue and realize their goals and see that others see those goals as legitimate [16] and achievable. Therefore, educators may become facilitators of hope by recognizing and better understanding the power of the experiences all students bring into the classroom. In other words, educators must not immediately position dominant epistemological narratives about the world or about STEM as truth and instead work toward better understanding how STEM connects and matters to the communities of all students. Through these types of efforts, instructors can transmogrify traditional, restrictive classrooms into environments of hope for students of Color, especially in social justice issues surrounding STEM.

By restoring hope, instructors open the gateway to transformative education with the purpose of students progressing beyond detriment through the creation of a more inclusive and multicultural classroom. Transformative learning empowers those with the least likelihood of access to it to overcome disadvantaged situations in ways that can reduce prejudice [16]. Pathways in education that promote collective inclusion strengthen confidence, personal control, and purposeful engagement [16]. The foundational essentials of a transformative education incorporate strategies, cooperatives, and reflection [16] in ways that lead us to empower classroom cultures.

The educators of today are shaping the thought leaders of tomorrow. With a staunch androcentric, dominant, and monocultural perspective, STEM faces limitations. Diversity advancement in STEM increases workforce talent, facilitates social justice and boosts objectivity [23]. It improves the conditions and relationships for multicultural communities working within STEM. Designing STEM with multicultural practices at its heart constructs a prosperous workplace and learning environment with various mentors, diverse thinking, and improved learning that heightens merit and immensely benefits scientific communities [23]. Therefore, educators have the ability to craft inclusive connections by operating with Freirean pedagogies in their classrooms and enhancing the workforce with diverse candidates.

### **Concluding Remarks**

Critical consciousness is not innate and requires full immersion into the process. By engaging in raising awareness components of diversity exposure, critical incidents, and self-reflection in phase one, a light bulb (aha moment) flickers and ignites the next phase of the framework. The transition into phase two builds momentum toward critical consciousness. However, we must sustain perpetual motion through continuous involvement, social justice engagement and coalition building, and intergroup relationship building. The two phases are dovetailed to build off each other to continue critical consciousness growth in profound and meaningful ways. From the development of this critical consciousness, educators become aware of the unjust imbalances surrounding students of Color in STEM spaces similar to the classroom setting. More importantly, we have the ability to recognize occasions of hope and hopelessness and move to action to become advocates and facilitators of hope. Freire's pedagogy of hope states the importance of hope and its roots in education to positively influence students and instructors to break away from inequitable classroom structures devoid of hope that continue to diminish students' of Color participation in STEM. By utilizing these Freirean pedagogies, we are empowering a genuine dialogue between students and instructors to work together toward equitable instruction, practices, and widening STEM spaces for all.

As a limitation, this work sits at the initial stage of our work currently. However, this initial work has paved the path toward the activation stage of our research journey through collaborative and empowering participatory action research methodology approaches to concretely implement Freirean pedagogies in STEM classrooms and demonstrate their effectiveness and need for multicultural education. STEM classrooms are at a disadvantage with growing students of Color populations in universities, but STEM fields still lag behind with students of Color participation similar to the engineering field. We see the need to continue to employ methods and utilize research approaches outside the traditional methodologies to explore every means possible to gravitate toward a multicultural STEM future. We hope our future work will continue constructing transformative and multicultural inclusion in STEM with students of Color.

As a final note, we encourage educators to become facilitators of hope to increase diversity and transform the dominant STEM monoculture into a multicultural one. Educators must think of themselves as allies, advocates and co-collaborators in this transformative process. Change may be difficult if it solely relies on the underrepresented alone. Let us not be haunted by the ghosts of a world that lacked multicultural competency and inclusion but create a world of hope where all who dream of science belong.

## Positionality Statement

Cassandra identifies as a multicultural Indigenous heterosexual cis-gendered woman. Daniel identifies as a White heterosexual cis-gendered male. Cassandra's entire academic and professional career has been in STEM with geosciences, technology, construction technology, and construction management. Cassandra teaches in classes in the construction management department and is a doctoral student in education, equity, and transformation with an emphasis on construction management. Dr. Birmingham's scholarship focuses on broadening participation in STEM education with a specific focus on equitable learning practices and consequential learning.

As a woman of Color in STEM, Cassandra's journey was not without its challenges, as these fields reflected an absence of diverse student populations, professors, leaders, multicultural inclusion strategies, and more. Several unsavory incidents in her STEM journey architected a hopeless and bleak future that created moments of capitulation to the STEM mass exodus of the underrepresented. Thankfully, Cassandra's advocates, allies, and multicultural support have derailed her exit and inspired hope. It has strengthened her passion, efforts, and research work to create hope in STEM transformative education for all. Cassandra's research work involves crafting multicultural education and competency to successfully support underrepresented students and faculty in STEM spaces as we all deserve the chance for a future with endless possibilities. Most importantly, Cassandra wishes for all those on the verge of losing hope to know she sees, hears, and understands them. She appreciates all the allies and advocates crafting space and helping turn STEM dreams into reality. This work is dedicated to you all to not lose hope or be afraid to dream. Dr. Birmingham engages in participatory research with youth, teachers, faculty, and community members to better understand and address issues of participation in STEM.

## References

- [1] B. Wong, Y.L.T. Chiu, Ó.M. Murray and J. Horsburgh, "End of the road? The career intentions of underrepresented STEM students in higher education," in *International Journal of STEM*, vol. 9, no. 51, pp. 1–12, Jul. 2002. [Online]. Available: <https://www.proquest.com>. [Accessed Jan 10, 2023].
- [2] B.M. Dewsbury, "Deep teaching in a college STEM classroom," *Cultural Studies of Science Education*, vol. 15, pp. 169–191, Mar. 2019. [Online]. Available: <https://www.proquest.com>. [Accessed Jan 10, 2023].
- [3] K.A. Griffin, D. Pérez II, A.P.E. Holmes, and C.E.P. Mayo, "Investing in the future: The importance of faculty mentoring in the development of students of color in STEM," *New Directions for Institutional Research*, no. 148, pp. 95–103, Dec. 2010. [Online]. Available: <https://onlinelibrary-wiley-com>. [Accessed Jan 10, 2023].
- [4] National Center for Education Statistics, "Characteristics of Postsecondary Faculty," U.S. Department of Education. Available: <https://nces.ed.gov/programs/coe/indicator/csc>. [Accessed Jan 10, 2023].

- [5] L.M. Landreman, P.M. King, C.J. Rasmussen, and C.X. Jiang, "A phenomenological study of the development of university educators' critical consciousness," *Journal of College Student Development*, vol. 48, no. 3, pp. 275–296, 2007. [Online]. Available: <https://muse-jhu-edu>. [Accessed Jan 10, 2023].
- [6] A. Singer, G. Montgomery, and S. Schmoll, "How to foster the formation of STEM identity: studying diversity in an authentic learning environment," *International Journal of STEM Education*, vol. 7, no. 57, pp. 1–12, 2020. [Online]. Available: <https://www.proquest.com>. [Accessed Jan 10, 2023].
- [7] M.J. Lee, J.D. Collins, S.A. Harwood, R. Mendenhall, and M.B. Hunt, "If you aren't White, Asian or Indian, you aren't an engineer: racial microaggressions in STEM education," *International Journal of STEM Education*, vol. 7, no. 48, pp. 1–16, 2020. [Online]. Available: <https://www.proquest.com>. [Accessed Jan 10, 2023].
- [8] H. Curtis-Boles, A.G. Chupina, and Y. Okubo, "Social Justice Challenges: Students of Color and Critical Incidents in the Graduate Classroom," *Training and Education in Professional Psychology*, vol. 14, no. 2, pp. 100–108, 2020. [Online]. Available: <http://web-s-ebshost.com>. [Accessed Jan 10, 2023].
- [9] National Center for Education Statistics, "Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021," National Science Foundation. [Online]. Available: <https://nces.nsf.gov/wmpd>. [Accessed Jan 10, 2023].
- [10] J.B. Main, L. Tan, M.F. Cox, E.O. McGee, and A. Katz, "The correlation between undergraduate student diversity and the representation of women of color faculty in engineering," *Journal of Engineering Education*, vol. 109, no. 4, pp. 843–864, Oct. 2020. [Online]. Available: <https://onlinelibrary-wiley-com>. [Accessed Jan 10, 2023].
- [11] M.L. Miles, A.J. Brockman, and D.E. Naphan-Kingery, "Invalidated identities: The disconfirming effects of racial microaggressions on Black doctoral students in STEM," *Journal of Research in Science Teaching*, vol. 57, no. 2, pp. 1–25, Jul. 2020. [Online]. Available: <https://onlinelibrary-wiley-com>. [Accessed Jan 10, 2023].
- [12] T. Nkrumah and K.A. Scott, "Mentoring in STEM higher education: a synthesis of the literature to (re)present the excluded women of color," *International Journal of STEM Science*, vol. 9, no. 50, pp. 1–23, 2022. [Online]. Available: <https://www.proquest.com>. [Accessed Jan 10, 2023].
- [13] D.R. Johnson, "Women of color in science, technology, engineering, and mathematics (STEM)," *New Directions for Institutional Research*, no. 152, pp. 75–85, 2011. [Online]. Available: <https://colostate.primo.exlibrisgroup.com>. [Accessed Jan 10, 2023].
- [14] J. Dale and E.J. Hyslop-Margison, *Paulo Freire teaching for freedom and transformation: the philosophical influences on the work of Paulo Freire*, New York, Springer, 2010.

- [15] P. Freire, *Pedagogy of the Oppressed*, New York: Seabury, 1970.
- [16] P. Howard, J. Butcher and L. Egan, “Transformative education: Pathways to identity, independence and hope,” *Gateway’s International Journal of Community Research and Engagement*, vol. 3, pp. 88–103, 2010. [Online]. Available: <https://colostate.primo.exlibrisgroup.com>. [Accessed Jan 10, 2023].
- [17] P. Allison and E. Pomeroy, “How Shall We ‘Know?’ Epistemological Concerns in Research in Experiential Education,” *Journal of Experimental Education*, vol. 23, no. 2, pp. 91–98, 2000. [Online]. Available: <https://journals-sagepub-com>. [Accessed Jan 10, 2023].
- [18] K. Stancin, P. Posic and D. Jaksic, “Ontologies in education – state of the art,” *Education and Informational Technologies*, vol. 25, no. 6, pp. 5301–5320, 2020. [Online]. Available: <https://link-springer-com>. [Accessed Jan 10, 2023].
- [19] L.R. Marks, A. Schimmel-Bristow, L.M. Harrell-Williams, C. Hargons, “Racial Discrimination and Risky Sex: Examining Cognitive-Emotional Factors in Black College Students,” *Counseling Psychologist*, vol. 50, no. 5, pp. 594–621, 2022. [Online]. <https://journals-sagepub-com>. Available: [Accessed Jan 10, 2023].
- [20] M. Ojala, “Hope and Anticipation in Education for a Sustainable Future,” *Futures: the journal of policy, planning and futures studies*, vol. 94, pp. 76–84, 2017. [Online]. Available: <https://doi.org/10.1016/j.futures.2016.10.004>. [Accessed Jan 10, 2023].
- [21] P. Freire, *Pedagogy of Hope: Reliving Pedagogy of the Oppressed*, Rio de Janeiro: Paz e Terra, 1992.
- [22] D. Webb, “Paulo Freire and the need for a kind of education in hope,” *Cambridge Journal of Education*, vol. 40, no. 4, pp. 327–339, 2010. [Online]. Available: <http://web-s-ebscobhost.com>. [Accessed Jan 10, 2023].
- [23] J.L. Smith, I.M. Handley, A.V. Zale, S. Rushing and M.A. Potvin, “Now Hiring! Empirically Testing a Three-Step Intervention to Increase Faculty Gender Diversity in STEM,” *Bioscience*, vol. 65, no. 11, pp. 1084–1087, 2015. [Online]. Available: <http://academin.oup.com>. [Accessed Jan 10, 2023].