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Black Post-Secondary Student Experiences in STEMM across the US and Canada: A Review of the Literature

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Author Comments:	This is a final resubmission with the unblinded manuscript. The Title Page has been updated to include the required information for Compliance with Ethical Standards.
Response to Reviewers:	The manuscript has now been unblinded.

April 5, 2025

Dear Guest Editors,

We re-submit this manuscript for review to the special issue, Black to the Future in the Canadian Journal of Science, Mathematics, and Technology Education. The manuscript entitled “Black Post-Secondary Student Experiences in STEMM across the US and Canada: A Review of the Literature” is a literature review paper based on themes from a panel that was organized through a BE-STEMM conference. The literature review provides a summary of insights on the Black post-secondary student experience across the US and Canada. The paper also provide recommendations on how the learnings in the United States might be applied to post-secondary institutions in Canada.

The paper has now been unblinded and finalized for publication.

Thank you for your support throughout this process.

Sincerely,

D’Andre Wilson-Ihejirika, Darren Butler, Tasha Zephirin, Yasmine Elmi, Amanda Tamakloe, and Anuli Ndubuisi

Title page (include authors names, contact details and affiliations, not disclosed to reviewers)

Black Post-Secondary Student Experiences in STEMM across the US and Canada: A Review of the Literature

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Black Post-Secondary Student Experiences in STEMM across the US and Canada: A Review of the Literature

Abstract

The experiences of Black students in Science, Technology, Engineering, Mathematics and Medicine/Health (STEMM) have not been prominently studied in Canadian higher education institutions (HEIs). Efforts to consolidate the literature on Black student experiences in STEMM have mostly focused on a single STEMM discipline (e.g., Engineering or Medicine), and have largely been based on the United States (US) or United Kingdom (UK) educational landscape. The Canadian Black Scientists Network (CBSN) established the BE-STEMM Beyond Borders initiative that is focused on fostering cross-border collaborations and sharing of promising practices for addressing racial equity in STEMM. This literature review examines Black students' experiences in STEMM across Canada and the United States to ascertain racial equity issues in STEMM education and promising practices for addressing them. This study is conceptually framed leveraging Social Cognitive Theory, Critical Race Theory and Intersectionality as frameworks, and analyzed across four theme areas identified at the BE-STEMM 2023 Conference namely; Inclusive Pedagogy, Mentorship, Extracurriculars / Co-curriculars, and Access to Career Pathways.

Keywords: Black, STEMM, Post-Secondary, Student Experience

Introduction

Canadian educators' efforts to address issues of racial equity have typically been independent to each institution, duplicative, and disconnected. While institutions are increasingly striving to tackle racial equity issues, their approach has arguably not translated to better academic experiences, higher achievement, and educational aspirations for Black students in Science, Technology, Engineering, Mathematics, and Medicine/Health (STEMM) fields. Aligned with fields represented in the Canadian Black Scientists Network (CBSN), in this paper, we explicitly highlight the inclusion of medicine within broader meanings associated with the STEM acronym (Zollman, 2012). Till date, the experiences of Black students in STEMM have not been prominently studied in Canadian higher education institutions (HEIs). While the experiences of Black STEMM students have been investigated in the US, a common thread across racial equity research in STEMM disciplines in the US is a need to critically examine how anti-Black racism manifests in STEMM cultures as a pathway to re-envision STEMM cultures (Holly, 2020; Morton et al., 2023). From our literature review, we observed that efforts to consolidate the literature on Black student experiences in STEMM have mostly focused on a single STEMM discipline (e.g., Engineering or Medicine) and have largely been based on the United States (US) or United Kingdom (UK) educational landscape. This highlights the need to reinforce the connections between practitioners and researchers across STEMM to allow for a more integrated and effective strategy for enhancing Black undergraduate experiences. This literature review examines Black students' experiences in STEMM across Canada and the United States to ascertain racial equity issues in STEMM education and promising practices for addressing them. This literature review offers insights into the US and Canadian Black experiences across multiple STEMM disciplines thereby supporting educators as a starting point to consider how we can transfer best practices across disciplines and geographical locations.

As expanded on in the literature review, while there are similarities amongst the experiences of Black post-secondary students in the US and Canada, the different national contexts will shape the research and practice insights on students' experiences.. Both the US and Canada have collected race-based data since the 1990s and the historical intent behind this practice often aligned more with monitoring rather than empowering marginalized groups, which has led to continued critiques regarding how these data serve—or fail—racialized communities. Race-based data have historically aligned with political and economic agendas, categorizing groups primarily for state interests namely in the US, which can hinder equitable public health strategies and contribute to systemic inequities rather than reduce them (Qiang et al., 2024). That being said, the data collected in the US is more systematically organized and includes detailed subcategories that can allow for more specific, population-focused insights.

Furthermore, the structural organization of education also diverges between the two countries. Canada's provincial versus the US's state system impacts the approach to addressing racial equity in higher education. The US, with Historically Black Colleges and Universities (HBCUs)

and broader systemic interventions, has a structure that can more directly support Black student networks and educational resilience. In contrast, Canada, without such institutions, faces additional challenges in providing culturally affirming spaces and mentoring support. Although emerging initiatives like the Canadian Black Scientists Network (CBSN) and the National Society of Black Engineers (NSBE) collegiate chapters aim to bridge these gaps, Canada's provincial governance may limit the scalability and impact of these efforts compared to the more unified frameworks in the US. Ultimately, these differences impact how universities respond to the complex needs of the diverse student population, government expectations, labor market demands and other stakeholder requirements. It also influences their ability to retain the independence necessary for fostering knowledge creation and dissemination (Eastman et al., 2019).

Furthermore, the historical contexts and demographic differences between the two nations are significant, with 13.6% of the US population identifying as Black (*US Census Bureau QuickFacts*, n.d.), compared to 3.5% in Canada (Government of Canada, 2019), potentially influencing the distinct experiences of Black students in each country. The smaller percentage of Black individuals in Canada, compared to the US, suggest a higher degree of marginalization in the Canadian context. Of those in the US that identify as Black, ~90% of them were born in the US (Anderson, 2015) , vs. those in Canada who identify as Black, only ~40% of them were born in Canada (*Black History Month 2022... by the Numbers*, n.d.) . This indicates that significantly more of the Black population in Canada are new immigrants, which can lead to differences in how communities and subsequently educational systems are structured. Moreover, the presence of HBCUs (Historically Black Colleges and Universities) in the US (Karkouti, 2016), which do not exist in Canada, presents opportunities for increased levels of engagement with peers, cultural affirmation and faculty diversity with associated mentorship initiatives (Jefferson et al., 2023). While a lack of diversity in higher education has been a growing concern in the United States for over two decades leading to the setup of these HBCUs, it has only recently become a focus area for Canadian institutions. There is an opportunity to better understand and synthesize the work across the US and Canada to potentially apply the learnings from the two decades of work in the US to the emerging work beginning to take place in Canada.

Background

CBSN and the BE-STEMM Beyond Borders Initiative

The Canadian Black Scientists Network (CBSN) is a national coalition of Black people possessing or pursuing higher degrees in Science, Technology, Engineering, Mathematics, and Medicine/Health (STEMM) that aims to promote Black inclusion while considering its complexity and intersectional identities (*About Us | Canadian Black Scientists*, n.d.) This network understands race as a socially constructed concept that was created to justify the marginalization of specific populations (Crenshaw, 1995). In 2022, CBSN launched the BE-

STEMM (Black Excellence in STEMM) Beyond Borders. This initiative aims to foster cross-border collaborations and share practices for addressing racial equity in STEMM (*BE-STEMM Beyond Borders | Canadian Black Scientists*, n.d.). The initiative was formed with four working group areas focused on: Leadership, Policy, Post-secondary education, and K-University Pathways.

The Post-Secondary working group brought together researchers from across the United States (US) and Canada to leverage their expertise to compare and contrast the post secondary student experience for Black students in STEMM and synthesize promising practices (*BE-STEMM Beyond Borders | Canadian Black Scientists*, n.d.).This is being done through collaborative discussions, panels and literature review.

As part of the CBSN coalition, Canadian members of the Post-Secondary working group organized a conference workshop at the second annual BE-STEMM 2023 Conference, where renowned Black researchers across Canada and the United States presented their research and initiatives relating to Black post-secondary student experiences in STEMM. The interactive workshop explored the trends, barriers, enabling factors, and positive initiatives surrounding post-secondary experiences for Black students in STEMM. The working group identified, in collaboration with CBSN leadership, four critical areas of focus when considering the Black student experience in STEMM: 1) Culturally Affirming Pedagogy in STEMM Curriculum 2) Mentorship and Student-Professor Relationships 3) Extracurricular and Co-curricular Activities, and 4) Exposure to Academic and Career Pathways.

Following the conference, these four themes were determined as a helpful starting point to leverage insights from established research strands and intervention in the US, and the opportunity to engage in collaborative conversations and shared learnings between researchers and practitioners in Canada and the US.

The Post Secondary working group was expanded to include additional researchers from the US in addition to Canada. The working group leveraged the outcomes from the 2023 BE-STEMM conference to begin a conceptual framing for a literature review to summarize research on the Black post-secondary student experiences in STEMM across the US and Canada. This paper synthesizes the findings from the literature review conducted by the members of the Post-Secondary working group.

Purpose and Research Questions

With the standing up of the Canadian Black Scientists Network (CBSN) in 2022 and the burgeoning work to advance Black people across Canada in STEMM, the BE-STEMM Beyond Borders initiative identified an opportunity to learn from the ongoing work in the US and potentially apply those learnings to Canada, considering the potential similarities between the two countries, as well as possible differences. The Post-secondary working group of the BE-

STEMM Beyond Borders initiative conducted a literature review based on the following research questions:

RQ1. What does the literature tell us about the Black post-secondary student experience in STEMM across the US and Canada?

RQ2. What strategies have been employed in the US that have shown to improve the Black post-secondary experience in STEMM that can be applied to a Canadian context?

Positionality of the Authors

The members of the postsecondary working group, as the authors of this work, acknowledge that our positionality has affected how we proceeded with this work (Secules et al., 2021). All of us identify as Black and are pursuing or have completed post-secondary and graduate level degrees in STEMM. All of the members of the postsecondary working group are also currently pursuing research that examines the educational experience in STEMM from a cultural or racialized lens. This collective positionality also varies for each of our individual positionalities, outlined below.

D'Andre Wilson-Ihejirika: I am a Black woman, born and raised in The Bahamas, who immigrated to Canada to pursue an undergraduate degree in chemical engineering at McGill University. During my undergraduate degree I was involved in extra-curricular and co-curricular activities that I feel have influenced my career paths. After working in Alberta in the Oil and Gas industry, I formed a non profit focused on engineering outreach and later pivoted my career into higher education and returned to school to complete my PhD. My PhD research is focused on understanding how the Canadian undergraduate student experience influences career pathways for Black engineering graduates.

Anuli Ndubuisi: I am an educator, engineer, researcher, and a Black Christian Nigerian-Canadian woman. I was born in Egypt where my mom was studying at Cairo University and later spent my childhood in the United States where my Dad was then studying at Vanderbilt University. Thereafter, we returned to Nigeria where I obtained my bachelor in engineering before immigrating to Canada about 5 years ago. I've had the privilege of working across multiple geographical locations and cultures around the world in my professional career leading to over a decade of experience in the engineering profession, education, and research. During this period, I completed an MBA at Manchester University, and embarked on a PhD program at the University of Toronto. My identity and experiences are reflected in my doctoral research and have motivated me to conduct this review. My research is broadly focused on global education experiences and supporting learning across boundaries — particularly with diverse groups in global learning settings, international contexts, internationally trained professionals, and complex collaboration efforts.

Yasmine Elmi: I am a Black Muslim woman of Djiboutian-Somali descent, born in Kenya and raised mostly in Canada from the age of three 3. I lived in Kenya and South Africa from the age of 13-15 and 15-18, respectively. I recognize how my racial identity intersects with other facets of my identity, such as my religion, gender, and culture, creating a unique lived experience that is both enriched and challenged by these intersections. I have been privileged with strong family

support, both emotionally and financially as well as over 6 years of university level education. I'm acutely aware of how this support and education have facilitated my access to opportunities, a privilege not universally shared by Black youth, who often face barriers due to systematic unequal access to resources. My identity, experiences, and understandings have imparted a distinct lens through which I approach this review, with an understanding deeply resonant with the experiences described here.

Tasha Zephirin: I am a Black woman of Barbadian descent, born in the US and raised in the Anglophone Caribbean, mainly Barbados. I pursued my undergraduate and graduate engineering education at historically and predominantly white institutions (HPWIs) in the US My research and practice experiences are grounded in non curricular interventions that broaden participation in engineering and related fields. Significant experience most relevant to this work includes researcher, practitioner, leadership, and general membership roles in professional societies that focus on the recruitment and retention of engineering students from racially and ethnically marginalized populations in engineering education. My lived experience as an engineering education Ph.D. candidate completing my dissertation research on how a collegiate NSBE chapter supports Black engineering student persistence strongly informs my current thinking on Black post-secondary student experiences.

Darren Butler: I am a Black Bahamian born and raised in The Bahamas. I moved to the United States to pursue secondary education. I obtained my undergraduate degree in Computer Science from Philander Smith College, an HBCU in Little Rock, Arkansas. I am pursuing my PhD in Human-Computer Interaction at Carnegie Mellon University. My experience as a Black person in technology has influenced my approach to research, teaching, and leadership with a goal of decolonizing STEM through culturally relevant educational technologies and experiences.

Amanda Tamakloe: I am a Black woman, born and raised in Ghana. I moved to Canada to pursue my undergraduate degree in Chemical Engineering at the University of Calgary. Throughout my undergraduate studies, I have been involved in various extracurriculars and research which have greatly contributed and shaped my experience. I am currently engaged in an engineering internship in the Energy Industry in Calgary, after which I will complete my final year of my undergraduate studies. My lived experiences have impacted my view on this topic as I deeply relate to most of the lived experiences explored in this review.

Considering the varied positionalities of the authors, and the collective positionality, we note that our positionalities influenced our research in a number of ways (Secules et al., 2021). We see that our positionality (1) allowed us to better align and empathize with the topic of the research, considering our lived experiences, (2) influenced our methodology as we have individually been conducting research in a related area and used that to guide our literature review (3) shaped our conceptual framework considering our proximity to the subject matter experts we called on for the previous panel and subsequent themes arising from the panel (4) influenced our analysis and findings, as we have expertise in these areas that allowed us to draw deeper insights and conclusions based on our own previous research.

Conceptual Framework

Our conceptual framework leverages Social Cognitive Theory, Critical Race Theory and Intersectionality as underlying theoretical frameworks, with considerations of cultural context. Social Cognitive Theory posits that learning and student experience is influenced by personal, behavioral and environmental factors. Critical Race Theory challenges institutional culture and examines it with a critical lens with an emphasis on race, to expose the systemic barriers and inequitable systems biased against racialized groups (Crenshaw, 1995; Delgado & Stefancic, 2017). Intersectionality acknowledges that there are different spheres of a person's identity that can create compounding and interdependent systems of inequity that are greater and more complex than just the sum of each sphere of identity (Crenshaw, 1991). This review looks at the intersections between Black Identity and STEMM Identity for post-secondary students. Structures of power and exclusion centered around race within STEMM cultures can be linked to underlying ideologies (Cech, 2014) and cultural norms resulting from the demographic makeup of STEMM fields (Morton et al., 2023; Secules, 2017). While we acknowledge distinct disciplinary cultures within STEMM fields represented within the BE-STEMM network, for the purposes of this broad scoping review we considered common dominant cultural ideologies (e.g. whiteness, competition, masculinity, meritocracy) (Cech, 2014; Morton et al., 2023; Secules, 2017) identified in science and engineering disciplines within the literature as attributes of a broader STEMM culture that can adversely impact the experience of students from marginalized populations and inhibit the innovative contributions of diverse STEMM fields.

Combining these theories, we examine the literature for aspects of the student experience in the institutional culture of post-secondary education, with a perspective of race, focusing on the Black student experience, while also considering the context of STEMM education, which has certain espoused values of technical focus, objectivity, meritocracy and acceptance of authority (Riley, 2008). The themes identified in the 2023 BE-STEMM conference expanded on the Social Cognitive Theory framing, as specific aspects of the post-secondary student experience influenced by personal, behavioral and environmental factors in the intersectional context of Black and STEMM experiences. These themes included: 1) Culturally Affirming Pedagogy in STEMM Curriculum 2) Mentorship and Student-Professor Relationships 3) Extracurricular and Co-curricular Activities 4) Exposure to Academic and Career Pathways.

We also consider the influence of country culture and the similarities and differences of the US vs. Canada, leveraging Meyer's Culture Map (Meyer, 2014) and Schein's Culture Triangle , which theorizes that institutional culture, and the outputs or artifacts of that culture, are influenced by espoused values, which are in turn influenced by underlying assumptions (Schein, 2010). For example, both countries lean towards task-based values over relationship based when developing trust and both countries have applications-first persuasion approaches (Meyer, 2014). Whereas Canadian values tend to lean to more consensus-based decision-making than the US, and Canadian values tend to be less confrontational than the US (Meyer, 2014). These country

values are influenced by underlying assumptions that can be based in the historical contexts of the country (e.g. history of slavery in each country) which also influences the political systems and the demographic differences of the country (i.e. higher Black immigrant population in Canada vs. higher Black domestic population in the US (Anderson, 2015; Government of Canada, 2019). These cultural values can all influence the similarities and differences in the policies and systems developed by post-secondary institutions in both countries, including the curriculum design in STEMM and the demographics of the student and professor populations, ultimately impacting the postsecondary student experience for Black students in STEMM.

Using these theoretical underpinnings, we review the literature for commonalities across the post-secondary experience in the various STEMM disciplines and examine the potential recommendations from the US that may be applicable to the Canadian postsecondary landscape for Black students.

Method

Our literature review took a modified version of the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) approach (Page et al., 2021) . PRISMA was designed primarily for systematic reviews of studies that evaluate health interventions. However its use has been broadened to systemic reviews evaluating other interventions such as social and educational interventions. The updated PRISMA 2020 Checklist comprises a 27-item checklist which provides a comprehensive framework for conducting a systematic review to improve their transparency, completeness and accuracy. While PRISMA provides a comprehensive framework for systematic review, we chose not to adhere strictly to it's guidelines for two reasons: 1) We leveraged our expertise of the subject matter by incorporating findings and insights from our prior research in Equity Diversity and Inclusion in various STEMM disciplines, as well as in Engineering Education, moving beyond PRISMA's initial systematic search stages, 2) our positionality and unique perspectives as Black post-secondary students played a significant and necessary role in guiding our literature section and analysis, diverging from PRISMA's more systematic methodology. Hence, we took the following steps to conduct our literature review:

1. Identified relevant literature from our previous research
2. Conducted literature search in various scholarly databases based on the limitations of our previous research
3. Screened the literature based on the inclusion and exclusion criteria
4. Themed the literature based on our conceptual framework
5. Reviewed and analyzed the findings

Although these five steps greatly draw from the 27-item checklist of the PRISMA method, it differs in some of the following ways: 1) The study began by identifying relevant works from the research experiences of the authors, rather than beginning with a literature search of scholarly databases. This includes more papers which may not have shown up in the literature search based solely on keywords. 2) Study risk of bias assessment: PRISMA method involves a specification of the methods used to assess risk of bias in the included studies which includes details of the tool or database used and how many reviewers assessed each study and whether they worked independently. For our study, we detailed the database used, the reviewer who conducted the search and the reason for inclusion or exclusion of various articles, though did not document how multiple reviewers assessed each study, 3) Unlike the PRISMA method, this study did not compare quantitative measures across the literature, due to the fact that our outcomes were more qualitative and based on pre-identified themes. 4) Unlike the PRISMA method, a method to assess the certainty in the body of evidence for an outcome was not assessed.

Data Collection

Based on the authors' previous reviews of collegiate STEM education literature, relevant papers were identified that met the inclusion criteria. We considered literature from different Science, Technology, Engineering, Mathematics and Medicine/Health disciplinary fields as contributing to insights on the Black student experience within a broader STEMM culture. The following databases were then utilized: SCOPUS, Wiley Online Library and the Carnegie Mellon Library Catalog. For different parts of the literature review, different keywords were used. With the most common general keyword being black and different variations of it such as "minorities", "racialized", "under-represented", "African American" and "African Canadian". The themes identified by the working group as a result of the 2023 BE-STEMM Conference were used to guide additional keywords. Those themes included 1) Culturally Affirming Pedagogy in STEMM Curriculum 2) Mentorship and Student-Professor Relationships 3) Extracurricular and Co-curricular Activities 4) Exposure to Academic and Career Pathways.

For example, when conducting the literature search on Culturally Relevant Pedagogy, keywords such as "Culturally responsive pedagogy", "Culturally affirming pedagogy", "culturally responsive teaching" were used. There were varying numbers of results ranging from 9 to 452 depending on the keywords used. Table 1 shows the keywords used and the results from the literature search.

[Table 1]

Data Analysis

The authors identified 47 papers that met the inclusion criteria for the literature review. Most of the articles identified in the data collection phase were excluded because of the 1) lack of relevance for the subject and grade level, 2) timelines, 3) lack of peer review. Leveraging the

conceptual framing, the literature review focused around the 4 identified theme areas: Inclusive Pedagogy, Mentorship, Extracurriculars / Co-curriculars, Access to Career Pathways. Table 2 shows the breakdown of papers by theme area. Table 3 shows the breakdown of the 47 papers identified based on geographical location, and Table 4 shows the breakdown by STEMM discipline.

[Table 2]

[Table 3]

[Table 4]

Findings and Discussion

Based on the Conceptual Framework, the analysis was broken out into the four main theme areas. Of the papers included, most spoke to Inclusive Pedagogy, Extracurriculars and Access to Pathways, with fewer speaking directly to "Mentorship", however the theme areas were inter-linked. The following sections analyze the papers based on the themed areas.

Culturally Relevant Pedagogy in STEMM Curriculum

In 1995, Gloria Ladson-Billings published her theoretical framework for culturally relevant pedagogy (CRP) (Ladson-Billings, 1995). Ladson-Billings proposed three criteria for culturally responsive pedagogy. Culturally relevant pedagogy produces students who can 1) achieve academic success, 2) demonstrate cultural competence, and 3) understand and critique the existing social order. Student intellectual growth enhances academic success. Student celebration of personal and other cultures enhances cultural competence. Student development of critical consciousness allows students to use knowledge gained in schools to address real-world socio-political problems (Ladson-Billings, 1995). To practice CRP, teachers consider three core components: conception of themselves and others; conception of knowledge; and the structure of social relations and interactions in the classroom (Ladson-Billings, 1995). Other terminologies used interchangeably with culturally relevant pedagogy in our discussion of the literature include Culturally Sustaining Pedagogy (Paris, 2012), Culturally Responsive Pedagogy (Gay, 2002), and Culturally Affirming pedagogy (Williams et al., 2021).

In response to research question 1, we sought to identify how Black post-secondary students experience Culturally Relevant Pedagogy based on prior literature from the U.S and Canada.

The systematic search yielded no papers on CRP explicitly focused on Black college students in Canada. However, we discuss how pedagogical strategies may be employed in Canada. In any event, the scarcity of papers suggests a need for additional research in Culturally Affirming Pedagogy for Black identities.

We organize our findings according to Williams et al's themes of HBCU admin and faculty culturally affirming practices (Williams et al., 2021). The major themes include cultural validation via community connection, and pedagogy informed by Black experiences and cultural knowledge.

Cultural validation via a community connection

Cultural validation via community connection refers to how administrators and faculty members create culturally validating environments by embracing Black students' cultural backgrounds (Williams et al., 2021). These environments help Black students build connections to the larger Black populations outside of the institution and other marginalized identities. In our literature search, we found the creation of cultural validations through community connection to be most prevalent in the natural sciences (Davies et al., 2023; Kishbaugh et al., 2018) and medical fields (Majewska et al., 2022; Winstead et al., 2022). Practices fostering community connection were facilitated as hands-on research experiences, service learning projects, and place-based learning. These practices supported science identity, knowledge, and interest.

Place-based learning engages students in their local community's physical environment, history, and culture. Davies et al. implemented a place-based mini-unit for community college students in New York that integrated the city's glacial history, reporting an increased Black students' sense of belonging in science (Davies et al, 2023). Research and service-learning experience in health have leveraged historical and ongoing health disparities in the Black community to connect to larger socio-political issues (Majewska et al., 2022; Winstead et al., 2022). For example, (Winstead et al., 2022) developed a general chemistry curriculum, where students conducted lab experiments to develop a public service announcement that communicates lifestyle changes and the prevalence of diabetes in the Black community.

Canadian institutions can bridge the gap in research by studying the community-centered practices in STEMM through a Black-specific lens at the postsecondary level, particularly outside of the medical and natural sciences. We interpret facilitating community connection in STEMM disciplines as positioning STEMM as a *mechanism* for social change and positioning Black students as *agents* of social change. Similarly, (Fleming et al., 2013) found that peer community engagement encourages undergraduate students to consider their personal identities as change agents. This reflects ideas of Techno-social change agents and STEM Literacy for learning. A technosocial change agent refers to "individuals who can challenge dominant

narratives and construct more liberating identities and social relations" (Scott & Garcia, 2016). Stem Literacy for Learning positions STEM learning not only as a societal and economic need, but a personal need (Zollman, 2012). These ideas have emerged from research focusing predominantly on K12 contexts, but there is a lack of research in culturally responsive pedagogy focusing on Black postsecondary students in STEMM.

The literature review suggested that instructors in health sciences attempt to foster community connection in students by addressing health disparities in the Black community in research or service learning projects. The search returned only deficit-based approaches to cultural validation via community connection. The implication of the finding is that there is an opportunity to create more asset-based approaches. Some studies leveraging service learning such as (Majewska et al., 2022) leveraged the design thinking model. They also framed community members as participants or stakeholders of STEMM projects. This is a common practice in the field of participatory speculative design.

Participatory Speculative Design (PSD) combines participatory design and speculative design, blending two widely used approaches in technology design to address complex social issues, including racial justice (Bray & Harrington, 2021). In participatory design, impacted stakeholders—often experts in their lived experiences but excluded from decision-making—are invited into the design process, fostering more equitable outcomes that reflect their needs and values. Speculative design, on the other hand, encourages people to envision possible futures, raising critical questions about values, politics, and societal implications. By combining these methods, PSD helps marginalized groups, including Black communities, explore positive, inclusive futures that they may have difficulty envisioning otherwise. For example, (Bray & Harrington, 2021) highlight how critical design thinking from an Afrofuturism lens centers Black communities in design speculation to drive equity-driven design outcomes and address community concerns. This approach could further support culturally relevant pedagogy by inviting the students to consider how the Black community can shape visions of a future of STEMM that address both current challenges and aspirations. This would position STEMM practices as meaningful tools for empowerment and progress.

A promising attribute of PSD is that it can take an asset-based approach to designing technology with community members. Scholarships such as, (Flint & Jaggers, 2021), suggest that students gain more positive outcomes with asset-based instruction that embraces their strengths, cultures, and resources. Studies of participatory speculative design prompted Black participants to not only consider potential harms, but also prosperous futures (Bray & Harrington, 2021). Thus, we consider that research and practice in culturally relevant pedagogy can benefit from the ideas and practices of participatory speculative design to strengthen cultural validation through community connection. This may be accomplished through pedagogy that positions STEMM practices as a mechanism to address present issues, and create prosperous futures for the Black community.

Pedagogy Informed by Black Experiences and Knowledge

William et al described practicing pedagogy informed by Black experience and knowledge as incorporating the experiences of Black people in research and the curriculum and promoting examples of Black excellence (Williams et al., 2021). The use of asset-based narratives of Black excellence and positive imagery of Black people to educate both students and the broader public can help more people embrace diverse students' cultural backgrounds in non-deficit ways. Approaches utilized to amplify Black voices positively have included reflections (Wilson-Ihejirika, 2023), ethnography (Ndubuisi et al., 2023) and storytelling (Moore, 2021). These strength-based framing of Black voices often make connections to local and global Black communities while recognizing the challenges and impact of both the mainstream and the hidden curriculum in their success stories. Incorporating Black experience and knowledge from within and beyond Canada as well as the broader African diaspora can help Canadian institutions familiarize students about Black experiences in the global world; make connections between different Black people's lived experiences and social issues internationally while building their cultural competence.

Research positions Black faculty as important disseminators of cultural knowledge (Sanczyk et al., 2021). Differences in identity between students and faculty can create friction (Erskine-Meusa, 2017). Previous work suggests that faculty identity influences an institution's availability to facilitate culturally affirming pedagogy. Black and White students can have differing experiences even before the admissions process begins (Barfield et al., 2012), hence exposure to Black faculty and their cultural knowledge could be an important intervention tool to support Black students. However, McCoy-Wilson (2020) suggests internalized structures of oppression, particularly internalized racism, can hinder students' ability to leverage Black faculty as disseminators of knowledge . Internalized racism is defined by Williams and Williams-Morris (2000) as "the acceptance, by marginalized racial populations, of the negative societal beliefs and stereotypes about themselves" (p. 255). McCoy-Wilson presented several critical incidents where internalized racism and racialized perceptions of Black faculty impede them from viewing Black professors as disseminators of knowledge. One critical incident included a Black female student who explained to a Black faculty member that she believed that "the faculty were incompetent because they were black" (p. 555). Thus, addressing internalized racism in students is a critical step in positioning Black faculty as dissmentors of knowledge. Including asset-based narratives of Black excellence and positive imagery of Black people is a potential culturally relevant pedagogy to meet this step. Doing so in Canada requires institutions to understand the deficit and asset-based narratives and stereotypes in and around Black Canadian communities.

Mentorship and Student-Professor Relationships

Our concept of mentoring emphasized teaching, professional and personal guidance, sponsorship, role modeling, and socialization into a profession (Cronan-Hillix et al., 1986; Rogers et al., 1990). The impact of mentorship from both internal sources (peer-to-peer, student-professor and academic support groups), as well as external guidance (professionals etc) cannot be disputed namely for a Black STEMM students' academic and professional identity development and persistence. The findings described below highlight why mentorship is important and how mentorship within disciplinary spaces can be achieved to support Black postsecondary students. Findings were primarily from studies based in the United States and set within the engineering and medicine domain.

Black Students Navigating Visibility and Invisibility

A theme in the literature within this review is the paradoxical experience of invisibility and hypervisibility faced by Black students. Many students, namely in engineering programs, expressed a sense of isolation, frequently finding themselves to be the sole Black person in various engineering settings (Blosser, 2020). They shared how unsettling it was to enter environments such as classrooms, events, job fairs, or internships, and be confronted with this reality. These situations frequently led to feelings of anxiety. At the same time, these same students also described the discomfort of "being one of the only ones" among their peers where their distinctive appearance made them exceptionally visible to their peers leading to a sensation of being under constant scrutiny (Blosser, 2020). These students can also be considered invisible in the eyes of institutions that don't provide support for them, further contributing to these challenging experiences (Ross & McGrade, 2016) discussed this at the community level, noting the high visibility and impact but limited structural support of black led mentorship programs on campuses . The absence of systematic recruitment approaches by governing institutions may limit the organic growth of such groups and may inadvertently overlook potential members.

A critical, yet often underexplored, dimension of Black students' experiences in post-secondary institutions absent from this review, due to limitations in the search methods and the inclusion/exclusion criteria, is the intersectionality of race with other identity markers such as gender, sexuality, and class. It is worth considering for future literature review how these intersecting identities can further complicate their academic and social experiences (Leyva et al., 2022) .

This concept of visibility and invisibility is crucial to consider in mentorship dynamics as well. Mentoring relationships are complex and for Black STEMM students' identity dimensions including race, ethnicity, and gender, impact not only how a mentor and mentee may perceive each other but also how they engage with the mentoring relationship in different cultural contexts and

with their different cultural backgrounds (Mondisa, 2018). Same-race mentorship and disciplinary relationships can have an affirming impact on Black STEMM students with a sense of shared cultural background. And yet this is often difficult to achieve when the majority of mentors at institutions are White. For instance, a cross-sectional descriptive study on mentoring relationships among medical students at the University of California, San Francisco, revealed that most mentors were White (68%) or Asian (13%), with only a small percentage being African American (5%), Latin American (5%), or other (9%) (Bright et al., 1998). Only 24% of minority students had minority mentors. Among African-American students, 33% had African American mentors, while 18% of Latin American students had Latin American mentors.

Professor-student Relationships

The intricate connection between academic relationships and the development of a student's academic success is vividly showcased in these study's findings (Blosser, 2020). Students' interactions with professors and peers were not just limited to academic learning and networking; they were pivotal in bolstering the students' confidence and resilience (Fleming et al., 2013). This support system provided educational guidance, emotional encouragement, and a sense of solidarity, assuring students that they were not alone in their academic journey and supported their engineering identity development and persistence (Fleming et al., 2013). For both undergraduate and graduate students caring for the "whole student", inclusive of social identities that impact the STEM student experience is crucial (Burt et al., 2021; Mondisa, 2018). Insights into promising mentorship practices with 10 African American STEM PhD mentors with undergraduate mentoring experiences indicated they treated mentees like they would a family member, supporting mentees in developing their academic success plan by increasing awareness of resources and how to leverage them, and engaging an empathetic listening approach that also affirms the mentees experiences (Mondisa, 2018). Mentorship should include guidance that empowers and builds contextualized confidence in their academic and disciplinary cultures and effective mentoring requires tailored information of not only what to do but how to approach situations that are aligned with students' goals and needs (Mondisa & Main, 2021) . With varied precollege experiences, all students may not have the insider knowledge required to navigate academia. Furthermore, different institutional contexts will influence the social and cultural capital required to be successful within a specific degree program (e.g., some Black students may have less confidence and cultural knowledge to navigate a predominantly white environment) (Mondisa & Main, 2021). Extending these insights into the graduate student space and a potential gap in knowledge in a different phase of the academic journey, similar clear communication of expectations is important and (Burt et al., 2021) outlines a "Model of Wholeness in Graduate Advising" which outlines how the degree of care shown aligns with weak, basic, and strong advising experiences and relationships with graduate students and how faculty can consider integrating caring and wholeness-promoting practices at the individual and policy level.

The limited reported research on student-professor relationships as a form of mentorship is notable. However, there is evidence pointing to a significant gap in formal academic mentorship at the university, which adversely affects both the scope and effectiveness of mentorship services (Blosser, 2020). Considering professors are integral to the institution, it is plausible that an institution's reluctance to endorse Black-led mentorship programs could impede the participation of Black professors. Indeed, research results demonstrated that students often had to employ resourcefulness to navigate their coursework, relying on strategies like supplemental instruction and peer-facilitated study sessions, especially in challenging programs (Blosser, 2020). These findings highlight the critical need for more comprehensive mentorship programs. Such programs could greatly enhance the educational experience and identity development of students in engineering and other STEMM fields.

Socialization in STEM education and professions

Formal mentorship programs or mentorship components through institutional programming (e.g., faculty and staff driven programmatic efforts, undergraduate research opportunities, mentoring programs for undergraduate and graduate students) and peer groups and networks are a crucial support mechanism for Black postsecondary engineering students and facilitate meaningful relationships with a variety of stakeholders (Boyd-Sinkler et al., 2022; Holloman et al., 2021) . As expanded on further in the Extracurricular and Co-curricular section below, the mentorship elements of groups such as NSBE are incredibly motivating and reinforces their sense of belonging and integration into the STEMM community (Dickerson & Zephirin, 2017; Prewitt et al., 2007; Ross & McGrade, 2016) and can provide students with social capital in the form of insider knowledge that supports their navigation of academic and professional environments (Prewitt et al., 2007; Smith et al., 2021). Furthermore, students very involved in cocurricular activities likely hold leadership in NSBE, Black fraternities and sororities, or serve as MEP mentors through which they have the opportunity to develop professional skills that align with what is desired in the discipline (Garrett et al., 2022). Additionally, a systematic review published by Sambunjak et al. highlighted the significance of mentoring in the field of academic medicine (Sambunjak et al., 2006). This review pinpointed five research works which underscored the role of mentors as a crucial factor in advancing careers. The review concluded that mentorship plays a pivotal role in fostering personal growth, influencing career decisions, and enhancing research output. In contrast, other research, such as that by Jackson and colleagues, has indicated that a lack of mentorship can be a major barrier to career development in academic medicine, with 98% of academic clinicians citing it as a primary obstacle.

Extracurricular and Co-curricular Activities

Black students meaningfully engaged within various communities within and outside of the institution that supported their persistence and success. Communities of support within the institution included student clubs, peer groups, and institutional programmatic interventions and communities of support outside the institution included students' families (Boyd-Sinkler et al., 2022; Holloman et al., 2021). The profound impact of active involvement in ethnic professional organizations like the National Society of Black Engineers (NSBE) "as a community that provided purpose, support, and encouragement." (Ross & McGrade, 2016) was a commonly highlighted co curricular activity across the literature. NSBE was founded in the US and is prevalent across the United States with a mission to "increase the number of culturally responsible Black engineers who excel academically, succeed professionally, and positively impact the community". There are a number of chapters in Canada, particularly in Ontario and Quebec and while the impact of NSBE on students' journeys is less researched in the Canadian context, it is commonly referenced as an instrumental community for Black Canadian engineering students (Wilson-Ihejirika, 2023). Studies that have explored graduation rates for Black engineering students involved in local NSBE chapters at HPWIs show higher graduation rates between Black NSBE members and non-members (Dickerson & Zephirin, 2017; Ross & McGrade, 2016) and almost 50% less likely to leave in a given semester when compared with Black engineering students who were not involved (Hamil et al., n.d.). While empirical studies exploring graduation rates have not been conducted in Canada, engagement in NSBE is referenced as a key community of support across both the US and Canada in the personal experiences of Black engineering students that includes their affirmation as Black engineers, provides mentorship and diverse stakeholder relationship building opportunities, and increases exposure to career pathways (Ross & McGrade, 2016).

The majority US engineering education literature reviewed highlighted the importance of disciplinary student organizations and peer groups across different institutional contexts (e.g., (Fleming et al., 2013; Henderson et al., 2023; Ross & McGrade, 2016)).
However, it was evident that experiences outside the classroom were part of an integrated, diverse system of support through which students built their "circles of success" (Henderson et al., 2023). Black post-secondary students' experiences outside of the classroom supported them in a number of ways::

- Establishment of social and cultural capital (Belle et al., 2023; Ortiz et al., 2020)
- Sense of belonging (Ross & McGrade, 2016; Wilson-Ihejirika, 2023)
- Student empowerment and advocacy (Burke et al., 2021)

Social and Cultural Capital

Social capital theory is a theory that posits that interpersonal relations can create value for individuals by providing resources that can be used to achieve desired outcomes (Wright, 2015) which in the context of post-secondary education could be academic achievement, career development, etc. Meaningful engagement outside of the classroom with peers, faculty, and

family and other resources accessed through student-led and institutional led programmatic interventions supported Black postsecondary student persistence and degree attainment (Boyd-Sinkler et al., 2022; Holloman et al., 2021). Literature showed that engagement with Black campus clubs increased social capital for Black students in STEM (Belle et al., 2023). STEM focused student clubs helped to form a 'community of practice' where students could discuss difficult concepts and strengthen their understanding of STEM concepts (Fleming et al., 2013; Ross & McGrade, 2016). Clubs and industry associations also typically had conferences that allowed students to connect with other individuals who could help with career development (Ortiz et al., 2020; Sanchez et al., 2020) NSBE is instrumental to many Black engineering students in developing social capital through club involvement and participation in the NSBE conferences and conventions (Dickerson & Zephirin, 2017; Prewitt et al., 2007; Ross & McGrade, 2016; Smith et al., 2021; Wilson-Ihejirika, 2023).Scholars have also explored critical cultural capital frameworks such a community cultural wealth (Yosso, 2005) that center the forms of capital grounded in the experiences of communities of color to recognize and acknowledge the cultural assets students from racially marginalized populations draw on to succeed in White male dominant STEM environments. For example, one dimension of CCW, familial capital, i.e. "cultural knowledge nurtured among family and fictive kin that carry a sense of community, history, memory and cultural intuition," provides a useful lens to explore how families (Smith et al., 2021; Tolbert Smith, 2022) and extended family networks and family-like relationships and support systems (e.g., NSBE, Minority Engineering Programs (MEPs) support the persistence and success of Black engineering students (Henderson et al., 2023; Martin et al., 2016; Prewitt et al., 2007; Ross & McGrade, 2016; Tolbert Smith, 2022). Leveraging assets-based lenses like community cultural wealth and other success-oriented approaches provide insight into how Black students utilize their networks and resources within extracurricular and cocurricular spaces (Berhane, 2017; Dickerson & Zephirin, 2017; Henderson et al., 2023; Tolbert Smith, 2022).

Sense of Belonging

Due to Black students being marginalized in STEM, there can be challenges developing a sense of belonging in STEM post secondary programs. Some Black students mentioned difficulty in finding a sense of belonging in the more 'traditional' study group setting, mentioning that they did not have a real connection with them (Fleming et al., 2013), especially Black women (Blosser, 2020).

Student clubs and institutional-led student support offices (e.g., MEP) helped to enhance the sense of belonging and reduce feelings of isolation among Black STEM students. These communities of support operate as "counterspaces" where Black STEMM students find support as they address their identity, professional, familial, and well-being needs (Martin et al., 2016; Thomas et al., 2021). While ethnic professional organizations and student groups are commonly identified as supportive counterspaces for Black students, other sites include friend/peer groups, religious spaces, conferences that are aligned with students' values and cultural norms and are a

welcoming space for them where they find belonging and acceptance (Thomas et al., 2021). As one example, NSBE's mission resonates with members' cultural values and their mission-aligned ethos and programs provide a strong example of how students see alignment with their cultural values in a social and academic counterspace (Martin et al., 2016; Prewitt et al., 2007). NSBE membership has been vital in providing role models, instilling confidence, and nurturing pride in Black engineering students. The sight of peers and role models who are "people that looked like them" or share their ethnic background at professional events and conferences has been particularly motivating, enhancing their engagement and integration into the engineering community. Notably, active involvement in organization activities and leadership and mentorship roles were a common thread among participants which informed the finding that students' "perceived integration into NSBE" supported their subsequent integration into the university and discipline (Ross & McGrade, 2016).

How students engage with their racial identity development can inform how/if they choose to engage in majority Black spaces, a concept called identity saliency(Boyd-Sinkler et al., 2022). With a heterogeneous Black diaspora, it is important to consider within-group differences of Black STEMM students with different ethnicities who may have been born, raised, and/or educated outside of the US (e.g., first and second-generation African immigrants) as peer groups can sometimes mirror their own self-described racial, ethnic, and cultural identities" (Berhane, 2017).

Student empowerment and advocacy

As Black students in STEM, tend to feel isolation as well as hypervisibility and exposure to microaggressions (Blosser, 2020). Extracurriculars that center students' racial identity allow for Black students in STEMM to engage in discussions around equity and justice, affirm their experiences as Black students and are encouraged and empowered through connections with others with shared struggles on similar academic journeys, and develop a sense of pride seeing themselves and other Black students on similar academic and professional journeys (Prewitt et al., 2007; Ross & McGrade, 2016; Thomas et al., 2021). Furthermore, students' creation of "circles of success" (Henderson et al., 2023) and leadership within student organizations that support their success are evidence of how Black students play active roles in creating support for their persistence (Ross & McGrade, 2016). For example, (Henderson et al., 2023) show how Black students build "circles of success" that included themselves, their social networks (e.g., peers, faculty, family), and other resources (e.g., extracurricular and cocurricular activities, financial resources, academic resources) through which they gained the social support and cultural capital to persist in engineering. Supplementing these efforts with institutional and faculty support can strengthen efforts students engage in. For example, in Canada, formalized groups led by institution staff and faculty developed 'counterspaces' that allowed for a safe space to discuss EDI (equity, diversity, and inclusion) topics (Burke et al., 2021).

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Exposure to Academic and Career Pathways

K-12 Pathways to Post-secondary

Research globally indicates a systemic failure in the education of Black students, leading to their underperformance and inequitable career outcomes when compared to their South Asian, East Asian, and white counterparts (Ross & McGrade, 2016; Verdin & Godwin, 2015). Additional studies also emphasized the significance of various factors in shaping these outcomes, including the type of secondary school program and the pathways to university (direct or indirect) (James & Parekh, 2021). Notably, Black students entering university directly from high school show higher graduation rates than those following indirect pathways. Only 56.7% of Black students typically enroll in university directly after high school, and a mere 37.0% graduate when taking indirect paths (Blosser, 2020). This trend is alarmingly consistent with findings from both Canadian and US contexts, where Black students are more frequently placed in lower academic tracks in high school, negatively affecting their higher education prospects.

Pathways in Post-Secondary

Once enrolled in post-secondary institutions, Black students often face an environment that fails to acknowledge or integrate their lived experiences and histories into the curriculum, leading to a sense of alienation. This exclusionary atmosphere has been shown to significantly hinder their engagement and progress in university studies (Dickerson & Zephirin, 2017). Following this line of thinking, (James & Parekh, 2021). point outs the disconnect that students experience between university programs and the lived experiences as Black students, questioning the relevance and applicability of their degrees. This lack of connection can decrease the students' ability to envision contributing to their communities, potentially leading to a sense of hopelessness and resignation regarding their educational pursuits that carries over into their career pathway.

The career journeys of Black engineers can be influenced by factors such as underrepresentation in majority workplaces, graduation from specific institutions like HBCUs (Fletcher et al., 2021; Jefferson et al., 2023) , and affiliations with organizations like the National Society of Black Engineers (Wilson-Ihejirika, 2023). According to Dr. Scott A. Hofacker’s dissertation, these elements play a pivotal role in shaping career trajectories and self-perception in professional settings (Hofacker, 2014).

Experiential Learning and work-integrated learning can play a significant role in creating access to career pathways. Opportunities such as participation in internships, experiments / projects and research labs can expose students to pathways (Belle et al., 2023; Chatterjee et al., 2023; Ladeji-Osias et al., 2020; Preuss et al., 2022; Slack et al., 2024). Lack of institutional support for Black students to participate in internships, can lead to students turning to other avenues to try to gain

exposure, like through student clubs (Wilson-Ihejirika, 2023), or to other activities like hackathons (Belle et al., 2023).

Pre-exposure and conceptions about certain career paths can factor into the career decision making of Black STEM students, for example gender perceptions of certain STEM disciplines (Lord et al., 2014). Familial support and exposure, or familial capital, can influence a student's choice in STEM major or discipline as well as career choice point graduation, especially if Black students already have a close family member working in a STEM field (Ortiz et al., 2020). Stereotypes about certain STEM professions, for example STEM teachers having low pay (Neally, 2022), can also influence the decision-making and reinforce the underrepresentation of Black professionals in certain STEM fields. Lack of mentorship can lead to a 'leaky pipeline' and Black students not continuing to pursue careers in STEM beyond their first post-secondary degree (Freeman et al., 2016).

Transition from Education to Careers

When considering the transition from education to career, factors that began in one's educational pathways can carry over into their career journey. For example, racial underrepresentation in engineering begins in education and extends into the workplace. This underrepresentation is compounded by biases such as homophily, homosocial reproduction, and subtle forms of racism, which further impact career advancement and job satisfaction for Black engineers (Ross & McGrade, 2016).

Authority, power, and influence dynamics in predominantly white work environments also significantly affect the career journey of Black engineers. These dynamics manifest in various ways, including limited opportunities for learning and advancement due to power imbalances (Blosser, 2020).

Recommendations

Insights gained from the literature review will support Canadian faculty in identifying potential initial actions and considerations that can positively influence the experience of Black STEMM students and support both the quality of their experience and their successful degree attainment. However, this is only a starting place. In conducting the literature search, a promising consideration for our attempts to develop a collective impact guiding frame for the Canadian community for researchers and practitioners is "A Common agenda for the Advancement of Black Americans in Engineering" (London et al., 2022). This framing is illustrated in Figure 1 below.

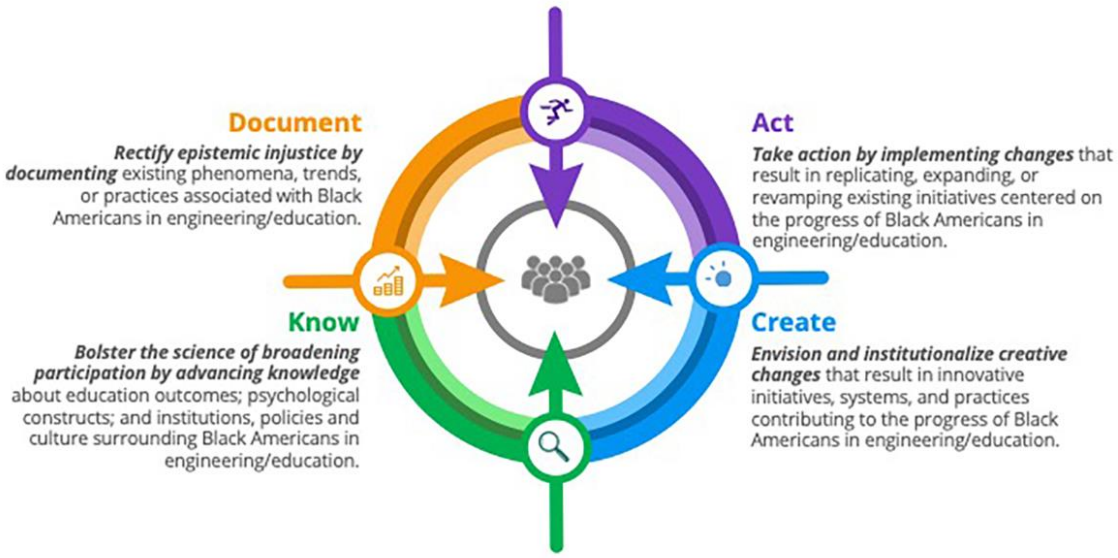

Figure 1: Overview of Document, Act, Create, Know Framework (London et al., 2022)

The integrated quadrant of actions developed through literature reviews and a Delphi study of experts can be used as a reflective tool as we consider similarities and differences in US and Canadian contexts. Based on the literature review, initial recommendations have been included in the framework of the quadrants below:

Know

- Additional study on STEMM in Canada is required to "investigate ways to promote a sense of belonging in engineering to reduce barriers that stem from a chilly climate, isolation, tokenism, and stress" (London et al., 2022). Gaining insights on the relationship between racism, gender, and STEM's values of meritocracy, objectivity, and technical focus within a Canadian context can help identify key characteristics that would impact knowledge transfer between US and Canada STEMM contexts and contribute to the re-envisioning of inclusive STEMM cultures (Holly, 2020; Morton et al., 2023).
- Additional study on how student groups are formed, both in and outside of the classroom, including study groups and project groups (Blosser, 2020). This can also provide more understanding on the role of identity, belonging, community, diversity and inclusion in building effective student or project groups.
- Better understand Black culture and history in the context of Canada and how that relates to STEMM higher education in Canada to inform culturally relevant pedagogy (Ladson-Billings, 1995). This knowledge can enable successful strategies of HBCUs (Historically Black Colleges and Universities) in the US for promoting Black excellence in STEMM to

be leveraged or adapted to build culturally relevant pedagogy that is suitable to the Canadian Black culture and history.

- Investigating the role of familial relationship on Black STEMM students (London et al., 2022) especially in the cultural and demographic context of Canada. Considering that the majority of the Black population in Canada are new immigrants and constitute a smaller percentage of the population in contrast to their US born counterparts, it is imperative to understand familial relationships and community support available to Black STEMM students.

Document

- Document and collect additional disaggregated race based data within Canadian post-secondary institutions (Belle et al., 2023; Burke et al., 2021) particularly on the Black student experience in STEMM. Additional sources of race based data may be explored such as national organizations and STEMM accreditation or regulatory bodies like the National Academy of Engineering and the National Survey of Student Engagement.
- Document the challenges that faculty encounter as they attempt to transform their curricula and pedagogy to be more racially inclusive to better understand how faculty can overcome these barriers. (London et al., 2022). This will allow for more positive student-faculty interactions which can be very influential to Black students in STEM. Other challenges that can be documented to support faculty development would be difficulties associated with building culturally competent faculty members and developing global competence curriculum in STEM (Jesiek, Shen, & Haller, 2012).

Create

- Design culturally relevant STEM media and literature to increase awareness and representation, especially within the context of Canada
- Build national platform(s) focused on broadening participation for Black people in STEM across Canada to provide a backbone organization for collective impact (London et al., 2022)
- Consider the creation and development of Black serving postsecondary institutions, modeling after the HBCU (historically black college and university) in the United States (Fleming et al., 2013; Williams et al., 2021; Harrington, 2022; London et al., 2022)
- Design internship and research experiences for Black students that create access and expose students to career pathways
- Create Black focused mentorship programs for Black students in STEMM

Act

- Developing a critical mass of Black students to combat isolation and hypervisibility (Blosser, 2020). This could be done through increased K-12 outreach and STEM access initiatives (Burke et al., 2021) and “Revamp admission criteria to ensure decisions are data-driven, holistic, and reward various kinds of capital” (London et al., 2022)

- Continuing to support the creation of counterspaces for example through clubs like the National Society of Black engineers (Blosser, 2020; Dickerson & Zephirin, 2017; Ross & McGrade, 2016; Wilson-Ihejirika, 2023)

We also recommend a parallel Delphi study of Canadian subject matter experts as we continue to build our own research enterprise to capture the knowledge of those currently engaged in supporting Black students in STEMM.

Limitations

Through this work to review the literature, there were several potential limitations identified. The foremost of which is the lack of literature published in Canada. This paper originally sought to compare the Black Post-Secondary Experience in STEMM between the US and Canada, however due to lack of literature in Canada, the findings are broadly focused across North America and skewed towards the US. There does appear to be more research beginning to emerge in this space within Canada, and it may be beneficial to conduct a subsequent literature review in future years to see how the body of literature may have changed. Furthermore, there is a need to identify key contextual considerations that can guide educators' understanding and evaluation of promising strategy transfer between the US and Canada.

Notably, in both the US and Canada, many papers reference underrepresented minorities (URM) or visible minorities, or in other ways group minority groups together. Due to our exclusion criteria, these papers were excluded if they did not specifically reference the Black experience in STEMM.

It should also be noted that as the positionality of the authors are primarily based in engineering contexts, much of the literature did focus on engineering student experiences, however the methodology did include a literature search across all STEMM disciplines.

Conclusion

This literature review highlighted some of the various aspects of the Black Post-Secondary Experience in STEMM within the US and Canada. Theme areas of Inclusive Pedagogy, Mentorship, Extra-Curricular and Access to Academic and Career Pathways were explored. It showed the limited amount of research that has been done in Canada to date, however it also highlighted the areas that can be focused on as recommendations to be implemented in Canada.

References

About Us | Canadian Black Scientists. (n.d.). Retrieved February 4, 2024, from https://blackscientists.ca/about-us/

Anderson, M. (2015, April 9). A Rising Share of the US Black Population Is Foreign Born. *Pew Research Center's Social & Demographic Trends Project*. https://www.pewresearch.org/social-trends/2015/04/09/a-rising-share-of-the-u-s-black-population-is-foreign-born/

Barfield, J. P., Cobler, D. C., Lam, E. T. C., Zhang, J., & Chitiyo, G. (2012). Differences between African-American and Caucasian students on enrollment influences and barriers in kinesiology-based allied health education programs. *Advances in Physiology Education*, *36*(2), 164–169. https://doi.org/10.1152/advan.00129.2011

Belle, A. B., Sutherland, C., Adesina, O. O., Kpodjedo, S., Ojong, N., & Cole, L. (2023). Bolstering the Persistence of Black Students in Undergraduate Computer Science Programs: A Systematic Mapping Study. *ACM Transactions on Computing Education*, *23*(4), 1–42. https://doi.org/10.1145/3617896

Berhane, B. T. (2017). *Networking 101: Exploring Within-Group Differences Between High-Achieving Black African and Black American Engineering Community College Student Peer Groups*.

BE-STEMM Beyond Borders | Canadian Black Scientists. (n.d.). Retrieved February 4, 2024, from https://blackscientists.ca/be-stemm-beyond-borders/

Black History Month 2022... By the numbers. (n.d.). Retrieved February 4, 2024, from https://www.statcan.gc.ca/en/dai/smr08/2022/smr08_259

Blosser, E. (2020). An examination of Black women's experiences in undergraduate engineering on a primarily white campus: Considering institutional strategies for change. *Journal of Engineering Education*, *109*(1), 52–71. https://doi.org/10.1002/jee.20304

Boyd-Sinkler, K. E., Holloman, T. K., Pee, C. M., Lee, W. C., London, J. S., Tech, V., Tech, V.,

Tech, V., & Tech, V. (2022). Black Students in Undergraduate Engineering Programs: A Qualitative Systematic Review. *The Journal of Negro Education*, *91*(1).

Bray, K., & Harrington, C. (2021). Speculative Blackness: Considering Afrofuturism in the Creation of Inclusive Speculative Design Probes. *Proceedings of the 2021 ACM Designing Interactive Systems Conference*, 1793–1806. https://doi.org/10.1145/3461778.3462002

Bright, C. M., Duefield, C. A., & Stone, V. E. (1998). Perceived barriers and biases in the medical education experience by gender and race. *Journal of the National Medical Association*, *90*(11), 681–688.

Burke, M., Hanson, C., & Abraham, C. (2021). Addressing Black Inclusivity Within a Canadian Post-secondary Engineering Faculty: A Critical Perspective. *Canadian Journal of Science, Mathematics and Technology Education*, *21*(2), 257–272. https://doi.org/10.1007/s42330-021-00155-5

Burt, B. A., Mccallum, C. M., Wallace, J. D., Roberson, J. J., Bonanno, A., & Boerman, E. (2021). Moving toward stronger advising practices: How Black males' experiences at HPWIs advance a more caring and wholeness-promoting framework for graduate advising. *Teachers College Record: The Voice of Scholarship in Education*, *123*(10), 31–58. https://doi.org/10.1177/01614681211059018

Cech, E. A. (2014). Culture of Disengagement in Engineering Education? Science, Technology, & Human Values, 39(1), 42–72. https://doi.org/10.1177/0162243913504305

Chatterjee, D., Jacob, G. A., Varvayanis, S. S., Wefes, I., Chalkley, R., Nogueira, A. T., Fuhrmann, C. N., Varadarajan, J., Hubbard, N. M., Gaines, C. H., Layton, R. L., & Chaudhary, S. (2023). Career self-efficacy disparities in underrepresented biomedical

scientist trainees. *PLOS ONE, 18*(3), e0280608. https://doi.org/10.1371/journal.pone.0280608

Crenshaw, K. (1991). Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color. Stanford Law Review, 43(6), 1241. https://doi.org/10.2307/1229039

Crenshaw, K. (Ed.). (1995). *Critical race theory: The key writings that formed the movement*. New Press : Distributed by W.W. Norton & Co.

Cronan-Hillix, T., Gensheimer, L. K., Cronan-Hillix, W. A., & Davidson, W. S. (1986). Students' Views of Mentors in Psychology Graduate Training. *Teaching of Psychology*, *13*(3), 123–127. https://doi.org/10.1207/s15328023top1303_5

Davies, R. M., Wolk-Stanley, J., Yuan, V., & Contino, J. (2023). Building science knowledge, identity, and interest using place-based learning with non-dominant urban undergraduate and high school students. *Journal of Geoscience Education*, *ahead-of-print*(ahead-of-print), 1–11. https://doi.org/10.1080/10899995.2023.2186762

Delgado, R., & Stefancic, J. (2017). Critical race theory: An introduction (Third edition). New York University Press.

Dickerson, D., & Zephirin, T. (2017). *Exploring the Association of a Cultural Engineering Student Organization Chapter with Student Success*. *Paper ID #20455*, 13.

Eastman, J. A., Jones, G. A., Begin-Caouette, O., Li, S. X., Noumi, C., & Trottier, C. (2019). Provincial Oversight and University Autonomy in Canada: Findings of a Comparative Study of Canadian University Governance. *Canadian Journal of Higher Education*, *48*(3), 65–81. https://doi.org/10.7202/1057129ar

Erskine-Meusa, D. (2017). African American Students in the Community College Classroom

with White Teachers. *Journal of Underrepresented and Minority Progress (Print)*, *1*(1), 66–79. https://doi.org/10.32674/jump.v1i1.37

Fleming, L., Smith, K., Williams, D., & Bliss, L. (2013). Engineering Identity of Black and Hispanic Undergraduates: The Impact of Minority Serving Institutions. *2013 ASEE Annual Conference & Exposition Proceedings*, 23.510.1-23.510.18. https://doi.org/10.18260/1-2--19524

Fletcher, T. L., Strong, A. C., Jefferson, J. P., Moten, J., Park, S. E., & Adams, D. J. (2021). Exploring the Excellence of HBCU Scientists and Engineers: The Development of an Alumni Success Instrument Linking Undergraduate Experiences to Graduate Pathways. *American Society for Engineering Education*.

Freeman, B. K., Landry, A., Trevino, R., Grande, D., & Shea, J. A. (2016). Understanding the Leaky Pipeline: Perceived Barriers to Pursuing a Career in Medicine or Dentistry Among Underrepresented-in-Medicine Undergraduate Students. *Academic Medicine*, *91*(7), 987–993. https://doi.org/10.1097/ACM.0000000000001020

Garrett, S. D., Martin, J. P., & Adams, S. G. (2022). Developing Nontechnical Professional Skills in African American Engineering Majors Through Co-Curricular Activities. *IEEE Transactions on Education*, *65*(3), 394–401. https://doi.org/10.1109/TE.2021.3120210

Gay, G. (2002). Preparing for Culturally Responsive Teaching. *Journal of Teacher Education*, *53*(2), 106–116. https://doi.org/10.1177/0022487102053002003

Government of Canada, S. C. (2019, February 27). *Diversity of the Black population in Canada: An overview*. https://www150.statcan.gc.ca/n1/pub/89-657-x/89-657-x2019002-eng.htm

Hamil, K.-A. D., Zephirin, T., & Dickerson, D. (n.d.). *Quantitative Methodological Approaches to Understand the Impact of Interventions: Exploring Black Engineering Student Success*.

Harrington, M. A. (2022). Diversity in neuroscience education: A perspective from a Historically Black institution. *Journal of Neuroscience Research, 100*(8), 1538–1544. https://doi.org/10.1002/jnr.24911

Henderson, J. A., Junqueira, W., Benjamin, L. S. S., Hines, E. M., Alarcón, J. D., Davis, J. L., & Cavazos, S. (2023). Circle of success—An interpretative phenomenological analysis of how Black engineering students experience success. *Journal of Engineering Education*, *112*(2), 403–417. https://doi.org/10.1002/jee.20509

Hofacker, S. (2014). Career Self-Efficacy of the Black Engineer in the US Government Workplace. *2014 ASEE Annual Conference & Exposition Proceedings*, 24.258.1-24.258.25. https://doi.org/10.18260/1-2--20149

Holloman, T. K., London, J., Lee, W. C., Pee, C. M., Ash, C. H., & Watford, B. (2021). Underrepresented and Overlooked: Insights from a Systematic Literature Review about Black Graduate Students in Engineering and Computer Science. *International Journal of Engineering Education*, *37*(2), 497–511.

Holly, J. (2020). Disentangling engineering education research's ANTI-BLACKNESS. Journal of Engineering Education, 109(4), 629–635. https://doi.org/10.1002/jee.20364

James, C. E., & Parekh, G. (2021). Fixed Trajectories: Race, Schooling, and Graduation from a Southern Ontario University. *Canadian Journal of Higher Education*, *51*(4), 67–84. https://doi.org/10.47678/cjhe.v51i4.189081

Jefferson, J., Park, S. E., Fletcher, T., Coso Strong, A., Nicholson, S., & Moten, J. (2023). Pillars of Success: The Role of Historically Black Colleges and Universities (HBCUs) in STEM Undergraduate Preparation Leading to Graduate School Pathways. *Journal of Women and Minorities in Science and Engineering*.

https://doi.org/10.1615/JWomenMinorScienEng.2023043944

Karkouti, I. M. (2016). Black Students' Educational Experiences in Predominantly White Universities: A Review of the Related Literature. *College Student Journal*, *50*(1), 59–70.

Kishbaugh, T. L., Cessna, S., Leaman, L., & Showalter, D. (2018). *Seeking To Improve Retention through Teaching Strategies and Peer Tutoring*. *1301*, 109–130. https://doi.org/10.1021/bk-2018-1301.ch007

Ladeji-Osias, J. "Kemi," Owolabi, O., Bista, K., Gaulee, U., Wemida, A., Efe, S., Oni, A., Ariyibi, A., Ndirangu, C., Olanrewaju, E., Lee, S., Alamu, O., Shokouhian, M., Ikiriko, S., & Kinyua, A. (2020). Initial Impact of an Experiment-centric Teaching Approach in Several STEM Disciplines. *2020 ASEE Virtual Annual Conference Content Access Proceedings*, 34829. https://doi.org/10.18260/1-2--34829

Ladson-Billings, G. (1995). Toward a Theory of Culturally Relevant Pedagogy. *American Educational Research Journal*, *32*(3), 465–491. https://doi.org/10.2307/1163320

Leyva, L. A., McNeill, R. T., Balmer, B. R., Marshall, B. L., King, V. E., & Alley, Z. D. (2022). Black Queer Students' Counter-Stories of Invisibility in Undergraduate STEM as a White, Cisheteropatriarchal Space. American Educational Research Journal, 59(5), 863–904. https://doi.org/10.3102/00028312221096455

London, J. S., Lee, W. C., Watford, B. A., Ash, C. D. H., Holloman, T., Pee, C. M., & Hampton, C. (2022). CLIMBING UPHILL: TOWARD A COMMON AGENDA FOR THE ADVANCEMENT OF BLACK AMERICANS IN ENGINEERING. *Journal of Women and Minorities in Science and Engineering*, *28*(3), 101–118. https://doi.org/10.1615/JWomenMinorScienEng.2022036617

Lord, S., Layton, R., Ohland, M., Brawner, C., & Long, R. (2014). A Multi-institution Study of

Student Demographics and Outcomes in Chemical Engineering. *Chemical Engineering Education*, *48*(4), Article 4.

Majewska, A. A., Stuart, J. D., Gray, K. M., Ryder, P. V., & Vereen, E. (2022). Development of a Men's Health course for first-year undergraduates using culturally responsive teaching strategies. *Health Education (Bradford, West Yorkshire, England)*, *122*(5), 535–545. https://doi.org/10.1108/HE-07-2021-0102

Martin, J., Revelo, R., Stefl, S., Garrett, S., & Adams, S. (2016). Ethnic Student Organizations in Engineering: Implications for Practice from Two Studies. *2016 ASEE Annual Conference & Exposition Proceedings*, 26744. https://doi.org/10.18260/p.26744

McCoy-Wilson, S. (2020). "We Have a Black Professor?" Rejecting African Americans as Disseminators of Knowledge. *Journal of Black Studies*, *51*(6), 545–564. https://doi.org/10.1177/0021934720925777

Meyer, E. (2014). The culture map: Breaking through the invisible boundaries of global business. PublicAffairs.

Mondisa, J.-L. (2018). Examining the Mentoring Approaches of African-American Mentors. *Journal of African American Studies*, *22*(4), 293–308. https://doi.org/10.1007/s12111-018-9411-y

Mondisa, J.-L., & Main, J. B. (2021). Mentors' Perceptions of Their African American Undergraduate Protégés' Needs and Challenges. *The Journal of Negro Education*, *90*(2).

Moore, C. (2021). *Telling a Different Story: A Counternarrative on Black Graduates' Experiences at Canadian Post-Secondary Institutions* [D.Soc.Sc., Royal Roads University (Canada)]. https://www.proquest.com/docview/2531224134/abstract/2A9A32C8614492FPQ/1

Morton, T. R., Agee, W., Ashad-Bishop, K. C., Banks, L. D., Barnett, Z. C., Bramlett, I. D., Brown, B., Gassmann, W., Grayson, K., Hollowell, G. P., Kaggwa, R., Kandlikar, G. S., Love, M., McCoy, W. N., Melton, M. A., Miles, M. L., Quinlan, C. L., Roby, R. S., Rorie, C. J., … Woodson, A. N. (2023). Re-Envisioning the Culture of Undergraduate Biology Education to Foster Black Student Success: A Clarion Call. CBE—Life Sciences Education, 22(4), es5. https://doi.org/10.1187/cbe.22-09-0175

Ndubuisi, A., Ovie, G., & Zhang, Z. K. (2023). Work in Progress: A Trio-Ethnography on Professional Identity Development of Internationally-Trained Minoritized Women Early-Career Researchers in Canada. *2023 ASEE Annual Conference & Exposition*. https://peer.asee.org/work-in-progress-a-trio-ethnography-on-professional-identity-development-of-internationally-trained-minoritized-women-early-career-researchers-in-canada

Neally, K. (2022). An analysis of the underrepresentation of minoritized groups in SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS education. *School Science and Mathematics*, *122*(5), 271–280. https://doi.org/10.1111/ssm.12542

Ortiz, Morton, Miles, & Roby. (2020). What About Us? Exploring the Challenges and Sources of Support Influencing Black Students' STEM Identity Development in Postsecondary Education. *The Journal of Negro Education*, *88*(3), 311. https://doi.org/10.7709/jnegroeducation.88.3.0311

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: Updated guidance

and exemplars for reporting systematic reviews. BMJ, 372, n160. https://doi.org/10.1136/bmj.n160

Paris, D. (2012). Culturally Sustaining Pedagogy: A Needed Change in Stance, Terminology, and Practice. *Educational Researcher*, *41*(3), 93–97. https://doi.org/10.3102/0013189X12441244

Preuss, M., Merriweather, S., Avila, J., Butler-Purry, K., Watson, K., Walton, S., Obiomon, P., Pezold, F., Murry, J., Roth, M., Kelley, J., & Lamm, H. (2022). The Effects of Undergraduate Research Experiences as Reported by Texas A&M University System Louis Stokes Alliance for Minority Participation Students. *Frontiers in Education*, *7*, 674761. https://doi.org/10.3389/feduc.2022.674761

Prewitt, A., Eugene, W., & Daily, S. (2007). Minority Retention And Success In Engineering: Diversifying The Pipeline Through The Development Of Social Capital. *2007 Annual Conference & Exposition Proceedings*, 12.1072.1-12.1072.14. https://doi.org/10.18260/1-2--2374

Qiang, V., Tope, P., Roberge, C., James, B., Elmi, Y. M., & Leggett, S. (2024). Race-based data alone are not enough: A call to action. *The Lancet*, *403*(10423), 228–231. https://doi.org/10.1016/S0140-6736(23)02779-4

Riley, D. (2008). Engineering and Social Justice. Springer International Publishing. https://doi.org/10.1007/978-3-031-79940-2

Rogers, J. C., Holloway, R. L., & Miller, S. M. (1990). Academic mentoring and family medicine's research productivity. *Family Medicine*, *22*(3), 186–190.

Ross, M., & McGrade, S. (2016). An Exploration into the Impacts of the National Society of Black Engineers (NSBE) on Student Persistence. *2016 ASEE Annual Conference &*

Exposition Proceedings, 27280. https://doi.org/10.18260/p.27280

Sambunjak, D., Straus, S. E., & Marušić, A. (2006). Mentoring in Academic Medicine: A Systematic Review. *JAMA*, *296*(9), 1103. https://doi.org/10.1001/jama.296.9.1103

Sanchez, Hypolite, Newman, & Cole. (2020). Black Women in STEM: The Need for Intersectional Supports in Professional Conference Spaces. *The Journal of Negro Education*, *88*(3), 297. https://doi.org/10.7709/jnegroeducation.88.3.0297

Sanczyk, A., Merriweather, L. R., Howell, C. D., & Douglas, N. C. (2021). STEM doctoral mentoring: A call for a conscious, culturally responsive journey. *International Journal of Mentoring and Coaching in Education*, *10*(3), 284–297. https://doi.org/10.1108/IJMCE-07-2020-0034

Schein, E. H. (2010). Organizational culture and leadership (4. ed). Jossey-Bass.

Scott, K. A., & Garcia, P. (2016). Techno-Social Change Agents: Fostering Activist Dispositions Among Girls of Color. *Meridians*, *15*(1), 65–85. https://doi.org/10.2979/meridians.15.1.05

Secules, S. (2017). Putting Diversity in Perspective: A Critical Cultural Historical Context for Representation in Engineering. 2017 ASEE Annual Conference & Exposition Proceedings, 28776. https://doi.org/10.18260/1-2--28776

Secules, S., McCall, C., Mejia, J. A., Beebe, C., Masters, A. S., L. Sánchez-Peña, M., & Svyantek, M. (2021). Positionality practices and dimensions of impact on equity research: A collaborative inquiry and call to the community. *Journal of Engineering Education*, *110*(1), 19–43. https://doi.org/10.1002/jee.20377

Slack, T., Davis, J. L., Benjamin, L. S. S., Hines, E. M., & Henderson, J. (2024). BLACK MALES IN STEM: EXPLORING FUTURE ENGINEERING GRADUATE SCHOOL

ASPIRATIONS OF UNDERGRADUATE BLACK MEN. *Journal of Women and Minorities in Science and Engineering*, *30*(1), 57–74. https://doi.org/10.1615/JWomenMinorScienEng.2023043030

Smith, C. A. S., Wao, H., Kersaint, G., Campbell-Montalvo, R., Gray-Ray, P., Puccia, E., Martin, J. P., Lee, R., Skvoretz, J., & MacDonald, G. (2021). Social Capital From Professional Engineering Organizations and the Persistence of Women and Underrepresented Minority Undergraduates. *Frontiers in Sociology*, *6*, 671856. https://doi.org/10.3389/fsoc.2021.671856

Thomas, K., Coley, B. C., Greene, M. L., & London, J. S. (2021). *Black Faces, White Spaces: Understanding the Role of Counterspaces in the Black Engineering Graduate Student Experience*.

Tolbert Smith, D. (2022). "They are here to support me": Community cultural wealth assets and precollege experiences of undergraduate Black men in engineering. *Journal of Engineering Education*, *111*(4), 750–769. https://doi.org/10.1002/jee.20480

US Census Bureau QuickFacts: United States. (n.d.). Retrieved February 4, 2024, from https://www.census.gov/quickfacts/fact/table/US/PST045222

Verdin, D., & Godwin, A. (2015). First in the family: A comparison of first-generation and non-first-generation engineering college students. *2015 IEEE Frontiers in Education Conference (FIE)*, 1–8. https://doi.org/10.1109/FIE.2015.7344359

Williams, K. L., Russell, A., & Summerville, K. (2021). Centering Blackness: An Examination of Culturally-Affirming Pedagogy and Practices Enacted by HBCU Administrators and Faculty Members. *Innovative Higher Education*, *46*(6), 733–757. https://doi.org/10.1007/s10755-021-09562-w

Wilson-Ihejirika, D. (2023, June). Reflections on my engineering student experience and career path: Exploring my positionality and the impact to my PhD research. *Conference Proceedings 2023 Canadian Engineering Education Association-Association Canadienne de l'éducation En Génie*. Conference Proceedings 2023 Canadian Engineering Education Association-Association canadienne de l'éducation en génie, Okanagan College & UBC-Okanagan, Kelowna, BC.

Winstead, A. J., McCarthy, P. C., Rice, D. S., & Nyambura, G. W. (2022). Linking Chemistry to Community: Integration of Culturally Responsive Teaching into General Chemistry I Laboratory in a Remote Setting. *Journal of Chemical Education*. https://doi.org/10.1021/acsjchemed.1c00494

Wright, J. D. (2015). *International encyclopedia of the social & behavioral sciences* (2nd edition). Elsevier.

Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education, 8*(1), 69–91. https://doi.org/10.1080/1361332052000341006

Zollman, A. (2012). Learning for STEM Literacy: STEM Literacy for Learning. *School Science and Mathematics*, *112*(1), 12–19. https://doi.org/10.1111/j.1949-8594.2012.00101.x

Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
The paper was a peer reviewed paper from a journal or conference proceedings	The paper was not subject to peer review
The paper had a focus on the Black post-secondary experience in STEMM, including college and university experiences, both undergraduate and graduate	The paper focused on K-12 student experiences
The paper specifically looked at the Black student experience	The paper had a general focus on minorities or underrepresented groups, with no specific focus on the Black student experience
The paper specifically focused on the Black student experience in STEMM disciplines	The paper focused on Black student experiences broadly with no specific focus on STEMM disciplines
The scope of the paper was based in the US or Canada or across North America	The scope of the paper was focused outside of North America

Table 2: Number of Papers Identified by Theme Area

Theme area	Number of Papers identified
Culturally Affirming/Inclusive Pedagogy	3 specific to this theme, 10 total
Mentorship and Student-Professor Relationships	5 specific to this theme, 28 total
Extracurricular and Co-curricular Activities	8 specific to this theme, 26 total
Exposure and Access to Academic and Career Pathways	9 specific to this theme, 21 total
Various / Multiple Themes	22

Table 3: Number of Papers Identified by Geographical Area

Geographical Area	Number of Papers Identified
US	42
Canada	4
Across North America	1

Table 4: Number of Papers Identified by STEMM Discipline

STEMM Discipline	Number of Papers Identified
Engineering	21
Medicine / Health	6
STEMM	18
Technology / Computer Science	2