Teacher training in the digital era: Diversity, equity, accessibility and inclusion

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1. Background

Canadian government bodies, industries, and communities have a responsibility to prioritize equitable, diverse, inclusive, and accessible (EDIA) education systems that consider intersectionalities and address systemic barriers faced by diverse youth in a variety of fields such as digital literacy and more largely Science, Technology, Engineering, and Mathematics (STEM). One of our primary area of research focus is adolescents' engagement with digital literacy, and by extension this includes STEM practices as it relates to provincial curricula in Canada. While digital literacies are not the targeted focus of this review, the considerations offered impact the future of the digital economy. In sum, this knowledge synthesis review examines inclusive practices in K-12 STEM education, focusing on improving the participation of diverse youth in future professions in the digital economy.

2. Objectives

The objectives of this review were to:

- Identify studies in STEM and STEM-related education fields that address gender and race as part of their focus.
- Identify gaps and strengths in STEM and STEM-related studies to help researchers, administrators and educators create more EDIA education systems that prepare students for and promote future digital professions.

3. Results

To generate more EDIA futures for the digital economy, it is crucial that policies address structural racism and discrimination in education with a focus on:

- Curriculum reform that adopts culturally responsive and constructivist pedagogies informed by cultures, languages, and values with an EDIA focus.
- Culturally inclusive teaching practices that are consistently integrated into classrooms and are supported by professional development with an EDIA focus.
- Support systems that provide access to Elders, teachers, staff, and mentors who are reflective of students' diverse lived experiences, as well as access to programs and services that provide academic, financial, cultural, and mental health and wellness resources.
- Community collaboration and input into decision-making processes related to curricula and service to support underrepresented students.
- Future research into how the complexities of intersectionality impact student retention and persistence in both STEM and STEM-related education and careers.

4. Key Messages

Across the studies we reviewed, there is an underlying and common thread across the research evidence that points to ongoing EDIA challenges in Canadian K-12 provincial schooling systems, including curriculum and policies that need improvement in EDIA measures. Our literature covers five major gap areas:

1. **Curriculum:** Curriculum reform is required to provide truly inclusive, diverse, and equitable access to and within STEM and STEM-related education. Curricula must be reconstructed to include more culturally responsive and constructivist pedagogical strategies.
2. **Teacher Training:** Constructivist, student-centered teaching practices include the incorporation of technology in the classroom and require skills and knowledge surrounding anti-racist, cultural competency, and proficiency, to support and communicate effectively with the diverse needs of students. Most studies suggest that this type of professional development is lacking across Canada.
3. **K-12 Student Needs:** Students who are marginalized by society often have a difficult time identifying with and feeling like they belong in STEM due to stereotypes imposed on them. STEM is seen as being modelled for white, middle-class, cisgender men. Stereotypes and biases in STEM must be challenged to create inclusive learning environments.
4. **Educational Policy and Structures:** Structural racism and discrimination in education policies continue to negatively impact diversity of participation in STEM. Future policy reform needs to address barriers and prioritize academic well-being of underrepresented students. Adequate funding and resources, as well as unambiguous policies and training, should be provided to increase student success and opportunities.
5. **Community Support:** Support systems and community connections are critical in increasing the advancement of underrepresented students in STEM. Family, Elders, teachers, administrators, educators, guidance counselors, support staff, peers, and community liaisons all have the potential to provide positive support to help students feel like they belong in STEM communities.

5. Methodology

This literature review was conducted by a diverse research team and included a comprehensive analysis of scientific literature on intersectionality, diversity, inclusion, and equity in STEM and STEM related education, n=61. Literature selected primarily focused on the last decade (2011 to 2021), n=57, and Canadian publications, n=32. American and other international literature was included where applicable and appropriate to the context, n=29. This selection of literature included diverse authors to ensure findings were reflective of the diversity of Canadian communities in which the K-12 system serves. Our draft report was reviewed by key community members for feedback and input.

1. Background

Digital and technological advancements in the last two decades have drastically changed the way that Canadians live, work, and access information. Following suit, much of the Canadian economy and workforce have been slowly transplanting themselves into the digital era, using digital literacies on the daily. This phenomenon has not only changed the way that Canadians work, but has also created jobs centered within the digital field. This phenomenon has significantly changed the needs and skills required within the Canadian workforce.

As a result, provinces and territories have begun developing coding and digital literacies curricula to meet new demands and standards reflected in the job market. In 2016, the provinces and territories leading the charge were British Columbia (who implemented mandatory coding classes in grades 6-9), Nova Scotia (who implemented coding classes for grades 4-6), and New Brunswick (who added coding to the technology curriculum in middle schools) (BC Ministry of Education, 2016; NB Department of Education and Early Childhood Development, 2016; Province of Nova Scotia, 2016). In 2017, Canada invested $50 million towards teaching coding, with a focus on attending to under-represented groups (Innovation, Science and Economic Development Canada, 2017). Ontario eventually followed British-Columbia, New Brunswick, and Nova Scotia by implementing a pilot program to integrate coding into curricula for grades 1-8 (Ontario Ministry of Education, 2020).

Despite the efforts by Canadian provinces and territories, the field of computer science and programming at the university level is mostly populated by white men (Frank, 2019; Wall, 2019). Girls not only remain under-represented, but also continue to show low interest in fields related to STEM and computer science (Gonsalves & Danielsson, 2020; Gosling & Gonsalves, 2020; Habig, Gupta, Levine & Adams, 2020; Joseph, 2020; Lemieux & Rowsell, 2021; Sengupta, Shanahan & Kim, 2019; Thomas, Howard & Shaffer, 2019). Some statistics and studies, however, neglect to consider diverse experiences, systematic barriers and structures, and intersecting identities within STEM and computer science (Charleston, Adserias, Lang & Jackson, 2014; Collins & Bilge, 2016; Crenshaw, 1989; Ireland et al., 2018; Mack, Taylor, Cantor & McDermott, 2014; Munro, 2018; O'Brien et al., 2015). The risk, therefore, is that despite government financing to increase diversity in computer science, and the increase of curricula designed towards coding and programming, under-represented students might continue to slip through the cracks, thus bringing little to no change to the currently white, male-dominated digital economy.

This disposition is problematic for several reasons. If the Canadian government wishes to increase and diversify its digital workforce, it must include ways to address systemic barriers in education and encourage success for all students. Furthermore, multiple studies have proven that a diverse workforce is significantly more successful than homogenous ones, since the inclusion of varied experiences and points of view reduces or eliminates gaps in thinking, encourages innovation, improves corporate strategy, and reduces conflict and poor social practices (Parker, Pelletier, & Croft, 2015). For the Canadian economy to speak to the diversity that it praises, and to ensure that decisions benefit all Canadians, it is imperative to look at ways to foster a diverse, equitable, accessible and inclusive digital workforce.

One of the ways to work towards more equitable futures for Canada's digital workforce is to increase the quality and quantity of mandatory digital literacy and coding curricula across the country. In order to make sure that this workforce is diverse and inclusive, we need to develop resources, curricula and educational policies that increase interest in STEM and digital literacy, value diversity and inclusion, and allow success for all students. The purpose of this project is thus to review research and literature that recognizes current strengths, but also identify gaps in existing resources to help properly inform future curricular and educational decisions that nurture strong foundations for EDIA in the digital workforce.

2. Objectives

This knowledge synthesis review examines EDIA practices in K-12 STEM education, focusing on improving the participation of diverse youth in future professions in the digital economy. Canadian government bodies, industries, and communities have a responsibility to prioritize equitable, diverse, inclusive, and accessible (EDIA) education systems that consider intersectionalities and address systemic barriers faced by diverse youth in a variety of fields such as digital literacy and more largely Science, Technology, Engineering, and Mathematics (STEM). This knowledge synthesis project includes a comprehensive analysis of scientific literature focused on underrepresented groups—women, racially minoritized, and gender variant students—in STEM, including literature on the realities of the intersectionalities of gender and race.

With a goal of addressing systemic barriers for underrepresented groups in alignment with the federal government's commitment to revitalizing the future of the digital economy, the objectives of this review were to:

- Identify studies in STEM and STEM-related education fields that address gender and race as part of their focus.
- Identify gaps and strengths in STEM and STEM-related studies to help researchers, administrators and educators create more EDIA education systems that prepare students for and promote future digital professions.

3. Methods

The research team for this project is culturally and gender diverse; the primary investigator is an assistant professor at the University of Montreal's Faculty of education and specializes in engagement and digital literacy. She holds a PhD from McGill University and completed a Postdoctoral Fellowship at Brock's Centre for Multiliteracies with Dr. Jennifer Rowsell. The research assistants Lisa Boyle, Emiyah Simmonds and Charlie Hook are students or graduates of B.Ed., MA and M.Ed. programs in education and education-related fields. Since this SSHRC-funded knowledge synthesis project took place in the middle of the COVID-19 pandemic, all team members conducted the bulk of their research independently and reported collectively, meeting over Skype for an hour once a week to discuss findings, structure, outcomes, methodology, and related developments. This research team values transparency and understands that each member's personal background impacts their approach and view of this work. Thus, each team has included a short positionality statement to introduce themselves to situate the lived experiences they bring to this project. This exercise provides further context to the findings presented in this review. In addition, we collected feedback from, and sought the expertise of, Black, 2SLGBTQ+, and Mi'kmaw people and we wish to acknowledge their work as part of this project. We recognize the expertise and advice of Mr. James Young, Mi'kmaw educator and Technology Integration Coach at Mi'kmaw Kina'matnewey school board in Membertou, Nova Scotia. We sought the feedback of Ms. Melina Kennedy, Mathematics Lead at the Department of Education and Early Childhood Development in Halifax, Nova Scotia, who has offered generous comments in acknowledging Black lives in STEM as well as EDIA practices. Finally, we welcomed the advice of Shelley Wallace, site coordinator at NSCC Akerley and member of Women Unlimited NS in terms of EDIA practices. We offered compensation for their knowledge and collaboration, and are dedicated to pursuing our working and community relationships, together. The team would also like to recognize Dr. Jennifer Adams and Dr. Pratim Sengupta who generously provided guidance and pointed us in the right direction with useful articles. We do not take their help for granted and want to acknowledge their guidance as part of this project.

Amélie Lemieux (she/her) is a 2SLGBTQ+, white, cisgender, early career researcher interested in the intersections between literacies, engagement, and the arts in high school settings. An assistant professor at the University of Montreal in the Département de didactique, Amélie has worked with diverse and underrepresented communities to study adolescents' engagement in literature, film, and technology writ large. She is interested in the changes these dispositions imply for social justice in provincial schooling systems in Canada.

Emiyah Simmonds (she/her) is a heterosexual, Black Nova Scotian with an undergraduate degree in biology and a certificate in forensic science. Simmonds is currently enrolled in a Bachelor of Education program, pursuing her dream of becoming a secondary school science teacher. As a Black, cisgender woman in STEM, Simmonds' many intersecting identities have made her aware of the disparities present between the experience and success of marginalized versus non-marginalized students in STEM. Her goal in entering the classroom is to create a learning environment that is safe and welcoming of all people, and to bring forth effective strategies that support diverse, equitable and inclusive education.

Lisa Boyle (she/her) is a heterosexual, white Nova Scotian who is a first-generation university graduate. She holds a degree in engineering and is currently enrolled in a Master of Education focused on learners with diverse needs and exceptionalities. Boyle has an extensive professional background in community college education in trades and technology, and teacher education. Boyle's commitment to inclusion is influenced by her studies and work as a woman in STEM, as an educator, and as a mother of a child with learning disabilities. Her work and educational studies are focused on equal access to education in supporting student success.

Charlotte Hook (she/her) is a queer and neurodivergent French Canadian woman with a background in museums, heritage, and history of science. Hook generally conducts, analyses, compiles, and presents research on ethical representation of diverse histories in heritage sites and the values we ascribe to our histories. Hook values interdisciplinarity and the use of a variety of mediums in her research, and aims to make her research relevant, inclusive, representative, and accessible to all to portray and identify more accurately the world and systems that we live in. She is passionate about the accessibility and availability of information to the public outside of academic and professional environments.

Although the focus of this review lays mainly on the diverse, inclusive, and equitable integration of coding and digital literacies curriculum in K-12 settings, the addition of mandatory coding to school curricula in Canada only began in 2016, with British-Columbia, Nova Scotia, and New Brunswick being leaders in first implementing this discipline (BC Ministry of Education, 2016; Province of Nova Scotia, 2016; NB Department of Education and Early Childhood Development, 2016). As a result, there is still limited literature on the inclusion of coding and computer science pedagogies in Canadian curricula, particularly in terms of such important dimensions as equity, diversity, inclusion, and accessibility, as well as the intersectionalities these dimensions bring forth. Although these curricular changes are necessary, they are occurring within a structure that benefits the white, cis, male, and able-bodied students already represented within STEM and computer science industries, and therefore disregard the ways in which these structures undermine the intersectionalities (Collins & Bilge, 2016; Crenshaw, 1989) that exist for underrepresented populations in STEM education. The research team therefore included literature on intersectionality, diversity, inclusion, and equity in STEM education and curricula in the review. This choice not only helps to serve the aims and goals of the knowledge synthesis review by pulling from a larger pool of related literature, but also acknowledges that many of the systematic barriers to diversity and intersectionality in STEM fields are also present in the fields of computer science and coding, as well as society at large. Finally, we further realize that some of the STEM articles do not necessarily address intersectionality as a topic or name it as such, but might do anyway in their narrative and analysis, which is why we included these findings in our review.

The first stage of the knowledge synthesis review began with a broad review of general literature on the topic of EDIA in STEM to get a lay of the available literature and help direct and focus the evolution of the project. Potential sources were accumulated in a shared Microsoft Excel spreadsheet (using Institutional OneDrive) that included authors, bibliographical entries, source links, and a brief breakdown of the year, field, topic, and geographical area covered, n=61. For this review and as mandated by SSHRC, the research team primarily focused on literature that was published in the last ten years (2011 to 2021), n=57, and that covered STEM and computer science/coding. In later stages of the research, additional criteria were added, including mention of K-12 education, and publication in Canada, n=32 due to the geographical nature of our review. American and international literature was included where applicable and appropriate to the context, n=29. Researchers also paid special attention to include and prioritize BIPOC and 2sLGBTQ+ voices in the consulted literature to ensure findings were reflective of the diversity of Canadian communities in which the K-12 system serves.

Once these first sources were identified in January 2021, they were taken up by members of the research team to read and summarize. All summaries were kept in a shared, secure Google document. Over the first few months of reviewing literature, team members noticed certain emerging themes and sorted reviews under five main categories: teacher training, curriculum, policies, K-12 student needs, and community support. These categories helped team members conceptualize and structure the review—these were ultimately kept in the final version of this report.

The next stage involved an evaluation of the team's current position within the explored literature (what we called a 'routine check'). The purpose of this recurring stage was to conceptualize the team's current efforts in terms of the review's two main guiding questions: (1) what studies in coding and STEM education address gender and race as part of their focus? and (2) how do these studies help researchers think about EDIA for future digital professions, especially considering the intersectionalities and systemic barriers that diverse youth face? The research team considered these two questions to identify trends and gaps in literature reviewed thus far.

From this point, we conducted a cross-sectional ProQuest and EBSCO database search to identify articles and research outputs that more specifically targeted both areas that were of interest, and those that were under-researched in the context of the review. This protocol ensured that the final collection of reviewed literature was well-rounded and far-reaching, meaning that the team could verify that the final report was complete and relevant, and accurately identified gaps in the research to provide tangible recommendations for policy and practice. Once these further sources were identified, the team continued to read, review, summarize, and synthesize identified literature according to previously stated research questions.

The research team then drafted the results of the review concurrently with one another, working with, and off each other's work. The implications were then written based on workable drafts, with each team member focusing on an area in which they developed affinities. This process allowed for all team members to cross-check their findings, fill in gaps as they arose, and build accurately and completely on the web of identified sources. In the final months of the process, team members reached out to Black, 2SLGBTQ+, and Mi'kmaw community members in education, STEM, and intersectionality to review and provide feedback on the report draft.

4. Results

The results of this report discuss strengths and gaps identified through our literature review focused on five key areas that influence successful implementation of EDIA practices that can positively influence inclusive future professions in the digital economy. The five key themes include: 1) curriculum, 2) teacher training, 3) K-12 student needs, 4) education policy and structures, and 5) community support.

4.1 Curriculum Strengths

Canada recognizes the importance of preparing youth for careers in STEM (Canada 2067, 2018a). This became evident in 2017 when the Canada 2067 report was launched with the intent to shape and inform the future of STEM learning in Canada's K-12 provincial curricula. Thousands of Canadians, including students and teachers, contributed to developing the Canada 2067 Learning Roadmap report. The report highlights six areas to which STEM education can be improved: 1) how teachers teach, 2) how students learn, 3) what students learn, 4) who is involved, 5) where education leads, and 6) equity and inclusivity in STEM education. Although this report does not explicitly focus on student groups that have been historically marginalized in STEM, it includes recommendations that consider inclusive practices to prepare Canadian youth to pursue diverse career paths in those areas. Another example of youth career preparation can be found in Nova Scotia. As such, the Technology Advantage Program Pilot directed towards Grade 9-10 youth, exemplifies how provinces such as NS have pushed for integrated technology courses that develop skills for future careers in that area.

There has also been a focus on improving inclusion in STEM at a provincial level. Provinces such as Québec, and Newfoundland and Labrador have adopted a mode of science education that focuses on self-directed learning through inquiry, where students learn about science in the same spirit as scientific methodology (Goodnough & Galway, 2019; Rahm, Potvin, & Vázquez-Abad, 2019). This type of student-centered learning often involves constructivist pedagogies. Constructivist pedagogies shift learning from passive to active by prompting inquiry-based learning activities whereby students ask questions, seek solutions to the problems highlighted by their inquiry, and examine the implications of their findings. Learning through inquiry promotes inter- and transdisciplinary learning, encourages students to work together and makes links between scientific methods and other areas, including literacy, history, and ethics (Castek, Hagerman & Woodard, 2019; Freiman, 2020; Noble et al., 2020; Rahm, Potvin & Vázquez-Abad, 2019; Sengupta, Shanahan & Kim, 2019). Inquiry-based learning emphasizes students' 21st century skills, including problem-solving, critical thinking, and various iterations of collaboration (Vossoughi & Bevan, 2014, p. 6). This approach nurtures students' interests while increasing their engagement in STEM-related fields and help in the development of inquiry-laden and problem-solving abilities (Kanter et al., 2011; King & Pringle, 2019; Vossoughi & Bevan, 2014).

In New Brunswick, the integration of maker education as a form of pedagogy promotes the concept of learning through inquiry and hands-on activities, where students are actively involved in making, exploring, and discovering solutions and answers to real-world problems by creating and engaging in inquiry through trial-and-error (Freiman, 2020). The integration of maker education in teaching and learning has provided opportunities for students to engage with tools, such as robotics kits, computer coding, programming software, and 3D printers, and participate in projects and activities that are reflective of students' lived experiences and interests. This engagement improves confidence and perseverance in students and promotes self-efficacy (Castek, Hagerman & Woodard, 2019; Freiman, 2020; Kang et al., 2019; Lemieux & Rowsell, 2020, 2021; Sutherland & Swayze, 2012). Students engaged in maker education who display self-efficacy have demonstrated their likeliness to pursue STEM-related careers and diversify the field (Archer, Dewitt, & Osborne, 2015; Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa, 2016; Parker, Pelletier, & Croft, 2015).

In addition to the many initiatives focused on inclusion in K-12 STEM education, such as the Technology Advantage Program Pilot in Nova Scotia, many out-of-school initiatives, projects, and programs also focus on supporting underrepresented students and their success in STEM (Cooper, 2020). Furthermore, K-12 STEM education needs more programs that connect Indigenous and Western ways of knowing both in urban centres, Indigenous, and local communities (Cooper, 2020; Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019; Rahm, Potvin & Vázquez-Abad, 2019; Sutherland & Swayze, 2012). Constructivist-oriented pedagogies, used in maker-related activities, regularly use computational modelling and other tools to guide students in learning through inquiry, which promotes a deeper understanding of complex systems and the inter-relations of various agents (Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019). These programs also promote concepts of emergence and inter-relations of various agents in complex systems, which are fundamentally ingrained in Indigenous ways of knowing (Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019; Sutherland & Swayze, 2012; Vossoughi, 2014). The use of constructivist pedagogies is a step in the right direction, whether in the school system or in out-of-school programs. This approach to learning has vast potential to influence the incorporation of Indigenous ways of knowing and computational models into Western education, thus not only helping to transform Canadian education and curricula, but also making it more relevant to Indigenous students and Canadian society at large (Goodnough & Galway, 2019; Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019; Sutherland & Swayze, 2012). Using computational models that are created or co-created by Indigenous stakeholders can strengthen students' sense of belonging in STEM fields and provide context for complex issues in STEM in a way that challenges the supposed objectivity of the field, thus encouraging more critical approaches to STEM and further decolonization of Western science curricula and disciplines (Das & Adams, 2019; Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019; Sutherland & Swayze, 2012). Similarly, representing a range of cultures and ways of thinking and knowing within Canadian curricula can change pedagogical landscapes in the pursuit of more socially just futures for the digital economy.

4.2 Curriculum Gaps

Although many Canadian provinces have undergone curriculum reforms in the last twenty years (Cooper, 2020; George, Maier & Robson, 2020), there remains a gap in the representation of diverse students in STEM education and ultimately in STEM careers (Goodnough & Galway 2019; Rahm, Potvin, & Vázquez-Abad, 2019). British Columbia, Nova Scotia, New Brunswick, and Ontario have begun to include coding and computer science curricular requirements to keep up with the demands of the Canadian economy and changing business landscape (BC Ministry of Education, 2016; NB Department of Education and Early Childhood Development, 2016; Ontario Ministry of Education, 2020; Province of Nova Scotia, 2016). The Truth and Reconciliation Commission of Canada: Calls to Action (2015) and the United Nations Declaration on the Rights of Indigenous Peoples (2007) have also identified curriculum reform as a requirement for EDIA education. These initiatives call for educational reform that address the educational gaps and aims to provide equal access to STEM education

(Cooper, 2020). Canadian students have also used their voices to identify the need for changes to be made to STEM curricula (Canada 2067, 2018b). The report highlights that students felt a lack of motivation in STEM education and shared that they did not see themselves or their interests—they expressed a desire to see their individual needs reflected. Students also pointed to seeing more interdisciplinarity within their course materials, more inquiry-based opportunities for them to use their critical thinking skills, problem-solving, and applying their knowledge to real-world issues (Canada 2067, 2018b; Takeuchi et al., 2020).

Another problem in both Canadian and American STEM curricula is the continued historical Eurocentric pedagogical approach and lack of cultural responsiveness (Das & Adams, 2019; Lam-Herrera, Ixkoj Ajkem Council, & Sengupta, 2019; McGee, 2020). STEM curricula that continue to perpetuate Eurocentric perspectives neglects Indigenous ways of knowing, being and doing, cultural relevance, and basic EDIA principles that support student learning (Cooper, 2020; Wiseman, Glanfield & Lunney Borden, 2017). Research has demonstrated that curricula informed by local cultures, languages, traditions, and values encourage engagement and improves the STEM learning process and academic success of underrepresented students (Cooper, 2020). By adopting these diverse ways of knowing, students ha more opportunities to meaningfully engage in STEM disciplines and pursue STEM education and careers (George, Maier & Robson, 2020; Ireland et al., 2018; Rahm, Potvin & Vázquez-Abad, 2019; Schad & Jones, 2020; Sutherland & Swayze, 2012). Approaches to teaching and learning need to consider the perspectives, needs, strengths, and values of underrepresented students, their families, and communities while providing opportunities for students. Heterogeneity in the language of STEM is central to student engagement and development of understanding of the complex nature of the ideas and concepts within these fields (Sengupta, 2020).

The discourse surrounding STEM education should address multiple dimensions such as culturally biased teaching and ways of knowing and the gaps in cultural competency (Das & Adams, 2019, Wiseman, Glanfield & Lunney Borden, 2017). STEM education needs to move away from a capitalist enterprise and should be reimagined as an area that can help construct human capability (Takeuchi & Dadkhahfard, 2019). A related immediate concern lies within the racial inequities in the realms of technological courses in schools and in the workforce. STEM can be enlivened through culture and its context as it adds urgency and an element of practicality to the curriculum (Das & Adams, 2019; King & Pringle, 2019). The conversation surrounding culturally responsive pedagogies needs to encompass the complex conditions, demographics, and realities of students who hold marginalized identities in terms of methods, protocols and content while keeping student needs at the forefront of the conversation (Cooper, 2020; Das & Adams, 2019; Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019; Philip et al., 2018 as cited in Sengupta, 2020; Sutherland & Swayze, 2012; Takeuchi et al., 2020). To truly create inclusive, diverse, and equitable access to STEM education and professions, traditional approaches and pedagogies must be disrupted as they are outdated and harmful to the identities and academic success of underrepresented students. Teachers and administrators must be encouraged and motivated to continuously question their own thoughts, values, ideologies, and beliefs on topics that are interlaced with inclusive education. Western STEM education is often idealized;

however, it is problematic as it does not engage with multiple perspectives and particularly the Indigenous perspective (Bang, Marin & Medin, 2018). Challenging norms can bring much needed perspectives to the classroom that would otherwise be silenced. Including the histories of underrepresented and marginalized groups in the classroom is required to design and support learning environments that honour and value the whole learner and improves learning for all students. The structure of these environments is important because it has the power to challenge, perpetuate or create inequities within a classroom (Takeuchi & Dadkhahfard, 2019).

This work to make STEM and STEM related education more equitable and inclusive is essential to allow students to see themselves in their classroom, learning environments, and curriculum—furthering the development of a "STEM identity" (Cross-Francis et al., 2019 p. 40). Although there is a multitude of studies and research that have contributed definitions of "STEM identity" (cf. Archer et al., 2015; Ireland et al.,2018; Kang et al., 2019; Schad & Jones, 2020; Sengupta, 2020), for our purposes here, we abide by Cross-Francis et al.'s definition, which refers to a unique and individual identity that is influenced by one's gender and racial identity. To support the development of STEM identities, every idea and how it is implemented into the curriculum and pedagogical strategies must be chosen and created with the intention of centering the voices of marginalized people so that STEM is inclusive of all learners (Harrison, Hurd & Brinegar, 2020; Sengupta, 2020).

Project-based learning when done with intent and purpose can be an example of a pedagogical approach that fosters inclusion by getting students involved with the community and providing opportunities for students to begin developing their STEM identity. When students are engaged in community-based project learning, they report feelings of inclusivity, and connectedness and are reportedly more engaged in their learning because it is more meaningful (Wiseman et al., 2020). For example, along with the students' improved comfort and confidence in their abilities, evaluation results indicated enhanced mathematical skills and understanding of STEM concepts (Wiseman et al., 2020). Including students, teachers, and community members in planning, teaching, and creating, community-oriented learning replaces colonial approaches to teaching and learning by connecting to real-world applications instead of prioritizing and depending on abstract learning and rote memorization (Wiseman et al., 2020). Meaningful, community-based, real-world learning allows students to engage deeply in learning across disciplines including environmental, ecological, urban and social sustainability, where they can develop STEM knowledge, skills and attitudes that help create interdisciplinary connections that mimic how STEM is learned and applied in the field (Das & Adams, 2019; Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019; Sengupta, Shanahan & Kim, 2019; Sutherland & Swayze, 2012; Wiseman et al., 2020).

Inclusion of student voice and perspectives are not only important in the development of STEM identities and improving student engagement, but they are also essential in identifying gaps in STEM curricula to support the creation of safe and inclusive learning environments (Schad & Jones, 2020). Student voice in the creation of learning activities, goal setting, and assessments, enhances opportunities for students to apply their learning through their own experiential lens and create relevant assessments that are informed by local cultures, languages, and values (Castek, Hagerman & Woodard, 2019; Wiseman et al., 2020). To truly be inclusive, student relationships must be collaborative versus consultative (Wiseman, Glanfield & Lunney Borden, 2017). The contribution of student voice in the design of learning and assessment will help to provide opportunities that empower, not undermine, students (Castek, Hagerman, & Woodard, 2019).

Technological innovations and computing skills must be integrated across all STEM disciplines to help students develop the skills needed for industry (Sengupta, Shanahan & Kim, 2019). The integration of technology in both teaching and learning can enhance STEM engagement and learning, and further students' working knowledge of technology. Despite the lack of representation and cultural responsiveness in STEM fields, educational practices that involve technology such as game design, coding, and mathematical reasoning, have shown to enhance learning for BIPOC students, who through use, were able to develop skills and gain expertise in technological fields of study (Sengupta, 2020). This need for access to technology and integration for teaching and learning has also been identified by students themselves, including the need and desire to have access to digital evaluation and feedback with access to grades anytime, anywhere (Canada 2067, 2018b). Access to and the integration of technologies in STEM classrooms can therefore not only increase students' technical abilities but can also play an important role in students' learning, even when structural issues are working against their success.

Although Canadian provinces seem to be succeeding at boosting interest in science (Freiman, 2020; Goodnough & Galway, 2019; Rahm, Potvin & Vázquez-Abad, 2019; Sutherland & Swayze, 2012), many are failing to produce scientifically and technologically literate populations or the desired increase in diversity in STEM and computer science fields (Goodnough & Galway, 2019; Rahm, Potvin, & Vázquez-Abad, 2019). Our review of available literature on science and technology curricula in Canada demonstrates that in addition to changes in curriculum, there exists many independent programs related to science and coding that operate separately from science curricula. For example, The Conference Board of Canada's Incorporating Indigenous Cultures and Realities in STEM (2020) report found more than 100 programs in Canada that were focused on Indigenous learners in STEM. Although well-intentioned and often well designed, these programs and science curricula often fail to relate to each other in a single cohesive mission (Rahm, Potvin & Vázquez-Abad, 2019) with very few initiatives incorporating evaluation to identify program impact and best practices (Cooper, 2020). For example, Québec boasts many after-school science programs—including many targeted towards girls, Black youth, and youth of colour—along with partnerships between scientists and Indigenous youth in the north of the province. However, many of these efforts do not correlate with an increased interest in, and pursuit of science-based careers among youth, considering that these programs operate separately from schools, and the messaging between schools and extra-curricular programing tends to contradict each other (Rahm, Potvin & Vázquez-Abad, 2019). In Québec, inclusive pedagogies such as maker education—which is generally more related to technological, computer, and coding education—are generally relegated to after-school programs. This phenomenon further contributes to the dissociation of scientific inquiry from an academic field or potential career (Rahm, Potvin & Vázquez-Abad, 2019). The students that these after-school programs are designed to benefit, are not always accessible or recognized within traditional modes of education (Rahm, Potvin & Vázquez-Abad, 2019). For example, many Indigenous students have after-school responsibilities or are bused to and from school, and unable to participate in these programs. This lack of accessibility further adds to the disparity that these programs aim to improve. More clear and direct links and collaboration between schools and extra-curricular scientific programming could ensure that messaging surrounding science is consistent and related to current contexts. As a result, students are less likely to receive contradicting science messages or lose interest between the gaps.

4.3 Teacher Training Strengths

In general, teachers believe that incorporating technology in the classroom improves student engagement and motivation (Freiman, 2020; Hechter & Vermette, 2013). Teacher attitude is important in engaging in professional development to implement a TPACK framework (Technological Pedagogical Content Knowledge) where technology is a significant component. TPACK attempts to highlight the relationships between various types of knowledge (technological, pedagogical, and content) as intersecting and interlocking groups that function in a collaborative and interactive manner within the teaching and learning process and classroom (Hechter & Vermette, 2013). Openness to continuing to develop and integrate constructivist pedagogies will support students in creating knowledge that helps them interpret and predict real-world phenomena. There is plenty of hands-on learning in a constructivist classroom that uses science-based technology to help students make meaningful connections (Freiman, 2020; Lam-Herrera, Ixkoj Ajkem Council & Sengupta, 2019). This student-centred pedagogy is often seen as the best teaching practice for science in K-12 learning spaces (Hechter & Vermette, 2013). Some studies have also found that playful engagement with a learning environment can help students see the connections between the real and theoretical worlds that they often learn in, making concepts both meaningful and relevant (Sengupta, Kim & Shanahan, 2019).

With the continued adoption of constructivist pedagogies, such as inquiry-based learning, maker education, and problem-based learning, teaching can shift away from imparting expert knowledge in a specific field towards developing critical thinking, self-directive, and leadership skills. Rather than teaching the subject matter directly to students, teachers guide students through their projects by supervising their use of methods of scientific inquiry, helping them use various technologies available in the labs, guiding them through their thinking process, encouraging teamwork between students, celebrating failure, and supporting perseverance through roadblocks (Freiman, 2020; Vossoughi & Bevan, 2014). However, Freiman (2020) notes that teachers often do not have any pre-existing knowledge of some of the scientific areas covered by student projects. Fortunately, the use of constructivist pedagogies help solves several problems related to teacher education and training in STEM fields. By eliminating the need for high standards of scientific knowledge for new teachers, teacher education programs can instead focus on developing inclusive teaching pedagogies and general science education learning such as problem-solving and adaptability (Freiman, 2020; Parker, Pelletier & Croft, 2015; Schad & Jones, 2020). This approach to learning increases feelings of self-efficacy and interest in science (Schad & Jones, 2020), in turn increasing overall motivation and performance, which has proven to be an issue for teachers in Newfoundland and Labrador, and Québec (Goodnough & Galway, 2019; Rahm, Potvin & Vázquez-Abad, 2019). Though a high standard of scientific knowledge is not needed for the lower levels of schooling to turn a science classroom into a constructivist science classroom, it may prove beneficial for more elementary school teachers to have some scientific background and knowledge to make their transition into constructivist pedagogies and learning smoother.

The introduction of maker-type pedagogies has demonstrated the benefit of increased partnerships with outside institutions and STEM professionals (Castek, Hagerman & Woodard, 2019; Freiman, 2020). This kind of partnership lends itself to better relationships between schools, universities, and museums, creating further opportunities for teacher training and development (Freiman, 2020; Goodnough & Galway, 2019; Rahm, Potvin & Vázquez-Abad, 2019). These partnerships and connections also allow teachers and educators to develop working relationships with STEM professionals. In developing programs and projects, teachers can work on their own skills with STEM experts before guiding students through learning. As such, constructivist pedagogies like makerspaces provide teachers with more professional development opportunities, whether through relationships with partner institutions or the experience they gain through their classroom activities. This kind of in-depth, collaborative relationship also helps prevent an over-reliance on third-party institutions and informal science education to teach scientific curriculum (Rahm, Potvin & Vázquez-Abad, 2019), since it maintains teacher involvement in STEM-related programming and continues to present science to students as an academic subject and potential career choice.

4.4 Teacher Training Gaps

The inclusion of more effective education and training for pre-service and in-service teachers emerged as a common theme throughout our literature review as essential components in improving diversity in STEM education and careers. Both pedagogical and technical professional development opportunities to know more about Indigenous (e.g., land-based learning), gender-diverse, and BIPOC perspectives, are required to develop inclusive STEM classrooms and improve persistent rates for underrepresented students (Canada 2067, 2018a; Ireland et al., 2018; Lee, 2015). As our findings on STEM and STEM related curricula identified, there is a need for integration of technology in teaching, learning, and assessment. Integration of technology was identified as a critical factor to engage and prepare underrepresented youth for future studies and careers in STEM (Canada 2067, 2018a; Canada 2067, 2018b; Castek, Hagerman & Woodard, 2019; Freiman, 2020; Goodnough & Galway, 2019; Rahm, Potvin & Vázquez-Abad, 2019). However, there remains several barriers keeping technology out of the classroom, including a lack of resources to integrate technology into teaching and learning, and a lack of teacher knowledge or skills needed to incorporate technology (Goodbough & Galway, 2019; Lee, 2015; Rahm, Potvin & Vázquez-Abad, 2019).

Many schools in Canada do not have training available to help teachers learn how to use technology and implement it effectively in their classrooms. This phenomenon is accelerated by the fact that teacher education programs focus on disciplines and content rather than technology education writ large (Roy, Gruslin & Poellhuber, 2021). Furthermore, teachers tend to find that technology is a superfluous part of the curriculum and that there is little time for it within their class schedules. The use of technology also does not come easily for some, but sustained professional development and metacognitive practices such as mapping prove to be engaging for teachers in higher education courses (Lemieux, 2021a, 2021b; Lemieux & Thériault, 2021). As such, teachers require professional development and support to improve their experience, comfort, and awareness of technology. These professional development opportunities need to focus on developing teaching competencies that transform traditional STEM pedagogies and support diverse learner needs (Castek, Hagerman & Woodard, 2019; Lee, 2015). The identified gaps in professional development include a lack of training in constructivist teaching practices such as inquiry-based learning, hands-on maker education, problem-based learning, and TPACK frameworks. More and more studies also push for the need to look at neomaterialist frameworks (Sheridan et al., 2020). There is an urgent need to include cultural proficiency, culturally relevant pedagogies, creating inclusive learning environments, and supporting learners with diverse needs (Canada 2067, 2018a; Castek, Hagerman & Woodard, 2019; George, Maier & Robson, 2020; Ireland et al., 2018; Lee, 2015; Whitley & Hollweck, 2020).

Another area that proves a challenge for the development of a more inclusive STEM classroom is the lack of teacher experience in addressing EDIA in their own classrooms. Many teachers feel that they do not currently have the right skills to guide and support students due to a lack of training (Whitley & Hollweck, 2020). Accommodating various student needs requires a building of capacities; however, developing this repertoire remains challenging as it takes time and resources. Results are either an immediate fix—often impractical in developing long-lasting skills and resources—or simple lip-service policies, leaving educators to fend for themselves in the classroom (George, Maier & Robson, 2020). These efforts should prove to be very valuable and used for a long time and in various classrooms. Creating more training programs may prove challenging since each province, city, and region has teachers with varying professional learning needs. The solution may, therefore, not be one-size-fits-all and needs to be adapted to various communities.

In addition to the skills needed to move towards culturally responsive pedagogies, a strong professional development emphasis must be placed on bridging the cultural competency gap (Canada 2067, 2018a; Castek, Hagerman & Woodard, 2019; Ireland et al., 2018). By developing cultural competence, teachers can explore different perspectives and ways of viewing the world and begin to challenge their personal biases on how STEM learning happens, what theories and perspectives influence teaching, and who STEM learners are (Archer, Dewitt & Osborne, 2015; Castek, Hagerman & Woodard, 2019). Professional development needs to provide opportunities for teachers to learn from community leaders such as the Elders present within many Indigenous communities (Wiseman, Glanfield & Lunney Borden, 2017) and, more importantly, there needs to be a sense of relationality with communities including giving back, being involved in ways that make sense to the communities, and advocating for Indigenous rights. This might be a first step in building the knowledge and skills needed to develop and incorporate EDIA pedagogies into their teaching practices (Castek, Hagerman & Woodard, 2019). Teachers need to foster learning environments that “leverage identity as a cultural asset with cultural integrity” (Ireland et al., 2018, p. 247). A pedagogical focus on racial, gender-specific strategies and connects Indigenous ways of knowing and cultural perspectives with Western science has shown to improve students’ engagement, learning, and academic success rates in STEM (Ireland et al., 2018; Cooper, 2020). By integrating more than one cultural perspective into learning, students are introduced to meaningful relations to space, time, and land (Cooper, 2020).

Communities of practice might be another way to support teachers in their EDIA training (Castek, Hagerman & Woodard, 2019; Goodnough & Galway, 2019; Schad & Jones, 2020) by providing opportunities for collaborative professional development, support systems, networking, and relationship-building with local communities to encourage meaningful learning opportunities (Castek, Hagerman & Woodard, 2019). Much like partnerships with institutions, mentorship and community resources can help teachers expand their own knowledge and self-efficacy in STEM classrooms (Castek, Hagerman & Woodard, 2019; Freiman, 2020; Goodnough & Galway, 2019; Rahm, Potvin & Vázquez-Abad, 2019; Freiman, 2020).The same resources could also help teachers build the confidence necessary to take charge and commit to creating inclusive classroom environments for Black and Indigenous students, students of colour, 2SLGBTQ+ students, neurodiverse students, and students whose identities are underrepresented in schools. The presence of support staff in schools and classrooms, not as aides but as equal members in the teaching community, can also help teachers share and develop various skills in everyday settings.

4.5 K-12 Student Needs Strengths

The increased utilization of maker education is a step in the right direction in encouraging diverse student groups to engage in STEM through project and problem-based learning, insofar as EDIA principles are respected and encouraged. When maker education is designed with contributions and consideration of diverse student perspectives, students feel more engaged in the learning process (Das & Adams, 2019; Freiman, 2020; Goodnough & Galway, 2019; Sutherland & Swayze, 2012; Wiseman et al., 2020). Students have identified that when participating in community-based projects, they feel learning is meaningful and engaging because of real-world applications to common problems (Wiseman et al., 2020). These findings support the findings that maker approaches to learning improve motivation and attitudes towards STEM especially when transdisciplinary learning is employed to acquire new knowledge and skills (Noble et al., 2020; Schad & Jones, 2020; Takeuchi et al., 2020). Another benefit of maker education is the focus on process in creating a final product (Lemieux, 2021a, 2021b). When students work towards solving a problem or creating a product that is relevant to their background, interests, or that can help their community in some way, they can see themselves, and this has shown to increase engagement, motivation and improve learning (Castek, Hagerman & Woodard, 2019; Lee, 2015).

Teachers who are committed to social justice issues often examine inequities present within racist, classist and sexist structures, practices and discourses. Their goal is often to guide students socially, politically, and academically to dismantle any disparities (Adams et al., 2018). However, the belief that equity efforts are limited to broadening participation, academic success, and making resources more readily available may be limited in what it truly means to dismantle and transform systems of power and inequity. Social justice work in schools does not always consider socio-political and environmental gaps. Some argue that empowerment directly in the classroom, when implemented by teachers and indirectly through the decisions made by the school, must be about supporting and validating students' families and communities. These decisions must consider diverse knowledge, skills, values, traditions, and cultures so that they can be incorporated on behalf of all students and their diverse backgrounds (Kayumova, McGuire & Cardello, 2018, as cited in Adams et al., 2018).

In the digital world, Black people, much like people of colour, are often lumped into the homogeneous identity of being "just" Black; however, the presence of various intersecting identities that are interconnected and inseparable must be considered as they uphold the social practices of exclusion (Gray, 2020). In Kishonna Gray's book *Intersectional Tech* (2020), she refers to the space to which Black bodies occupy in the digital and gaming worlds as "visual, textual and/or oral engagement[s] of the Black body" (Gray, 2020, p. 24). She maintains that this space can start in the digital world while simultaneously affecting the physical world and vice versa.

Virtual and digital spaces do not recognize women and BIPOC and other marginalized groups as legitimate participants, causing students to be excluded and their participation to be limited (Gray, 2020). This form of segregation mimics history in the way that it designates spaces as for whites only (Gray, 2020). These spaces are often linked to whiteness as things such as programming, machine algorithms, facial and voice recognition, and code continue to foster gender, racial, lingual, and able-bodied prejudice (Gray, 2020). Not only is it in the physical world that whiteness and masculinity is considered the norm but also in the digital world. When Black bodies are included in virtual and technological spaces, they are positioned for white consumers and audiences (Gray, 2020). These considerations are crucial in understanding how intersectionality works in both digital and physical spaces, where education is both present. Intersectionality emphasizes various systemic power dynamics that come about based on social interactions in most contexts, including institutional, cultural, and individual spaces (Adams et al., 2018). Intersectionality has been used more often to address inequality and discrimination within relation to STEM curriculum and fields (Adams et al., 2018). By addressing intersectionality and the interlacing of multiple social identities relating to gender, race, and ability, key concerns within schooling systems can be more readily and efficiently addressed.

4.6 K-12 Student Needs Gaps

Student voices are essential in EDIA reforms of STEM education. As such, Canadian students clearly articulated the need for and importance of improving STEM learning environments in K-12 schools in the Canada 2067 report (2018b). They described a need for school environments where students, teachers, and administrators' happiness were a core value. Furthermore, they expressed a desire to have a school culture that is supportive, encouraging, and inspiring, where they can participate in rich interactions with their teachers while being active agents in their education. Students want a STEM education that improves their critical thinking skills and supports their development to become contributing citizens to society.

A focus on student interest and motivation needs to be examined from kindergarten to high school to better understand when and why underrepresented students disengage from STEM learning. Interest and motivation in STEM seem to diminish as students age. It has been found that young children are most excited and motivated for mathematics through hands-on, play-based learning; this engagement with all areas of STEM is reported to lessen as students enter elementary school, middle school, then high school due to mundane curriculum practices and less hands-on learning (Harrison, Hurd & Brinegar, 2020; King & Pringle, 2019). At these levels, traditional STEM education practices rely on more Eurocentric approaches that include the memorization of information which does not prepare students for the demands of the current workforce, but rather provides a surface level understanding of STEM concepts. This causes students to lose interest and disengage from STEM and related disciplines.

Middle school is a critical time for youth to consider and determine career options which also seems to be the period in schooling where interest and participation in STEM diminish greatly even when grades in these areas are relatively high (Kang et al., 2019). A strong relationship remains between students' self-perception and their career aspirations. Because of this association, it is important to preserve middle schoolers' sense of self-efficacy. Researchers suggest that an identity gap is a manifestation of education debt which has caused women, and girls of colour specifically, to not feel welcomed for who they are and what they have to offer to STEM. Dr. Gloria Ladson-Billings has long advocated for the education of Black learners. Understanding these dimensions encompasses "historical, economic, socio-political, and moral components of inequality that shape the contours of our nation" (Ladson-Billings, 2013, p. 105). This collective responsibility also applies to Canada. Despite high achievement in STEM, due to this education debt Black girls in particular may still feel that they cannot identify with these disciplines (Archer et al., 2013 as cited in Kang et al., 2019; Ireland et al., 2018). This idea of STEM being for white, middle-class, cisgender men, makes creating an identity within these parameters essentially unthinkable for anyone who does not fit into these categories (McGee, 2020).

Enhancing middle school girls' participation in STEM seems to help with the creation of an identity within STEM and positively impacts and increases their self-perception (Cross-Francis et al., 2019; Ireland et al., 2018; Kang et al., 2019; Sengupta, 2020). It can be noted that girls' experiences with science are drastically different in school than outside of school (Ibe et al., 2018; Kang et al., 2019; Rahm, Malo & Lepage, 2016; Rahm, Potvin & Vàzquez-Abad, 2019). Participation in STEM outside of school is reported to positively affect girls' identification with STEM (King & Pringle, 2019). These out-of-school opportunities give a qualitatively different learning experience that breaks traditional STEM norms present within the schooling system (Rahm, Potvin & Vázquez-Abad, 2019). These considerations lead us to ask: how might this approach to informal learning be reinforced or adopted in classroom spaces? It is suggested that teachers ensure that their content includes examples that are relevant to a variety of groups such as female students, 2SLGBTQ+ students, students of colour, and other marginalized student groups by getting input from these students, their families, and their communities to make sure that the content being taught in the classroom is both engaging and meaningful (Ibe et al., 2018). This approach validates and mobilizes students' cultural resources, making the content and curriculum more personal, relatable, and applicable to current teaching and learning realities. Inquiry-based and problem-based learning are also often rooted in relevant and practical issues in which students, particularly girls of colour, seem to respond positively (Ireland et al., 2018; Mensah, 2021; Rahm, Potvin & Vàzquez-Abad, 2019). Includes a focus on racial and gender specific strategies in classrooms, so that students can engage in lessons at a deeper level because cultural knowledge is incorporated into their education (Ireland et al., 2018).

Mensah (2021) points out that curricula often becomes irrelevant to students of historically marginalized communities as they do not consider religion, language, socioeconomic status, racial and ethnic identities, and gender. Therefore, building curriculum and incorporating pedagogies that give reference to knowledge, linguistic strengths and other cultural areas yield promising results in STEM education (Mensah, 2021). In addition to these considerations, STEM needs to focus on reasoning and sense-making, giving some practicality to student learning, providing students with the skills required in STEM fields, and allowing students to envision themselves as STEM learners and professionals (Noble et al., 2020). However, to facilitate learning for students of various backgrounds, students must be provided equitable opportunities for success (King & Pringle, 2019). STEM education needs to generate well-rounded experiences so that students remain engaged and interested despite having a variety of individual interests and preferences. To support this thinking, integrating STEM into as many content areas and disciplines as possible can be an integral part of demonstrating that STEM is a transdisciplinary venture.

Determining why young women and girls so often do not pursue STEM fields of study remains a challenge as it extends intersectionality in multiple ways. Because of the effects of intersectionality, it is hard to pinpoint exactly what deters minority girls from STEM fields (Fernandez, 2021; Ireland et al., 2018). One assumption is that stereotypes held by teachers and the students themselves often steer them away from STEM fields, in turn lowering their desire to take on careers in these areas of study (King & Pringle, 2019).

It is suggested that racial equity in K-12 STEM classrooms and broader society could be advanced by identifying and addressing systemic racism and intersectional inequities both in the classroom and in taught disciplinary subjects (Archer, Dewitt & Osborne, 2015; Cooper, 2020; Das & Adams, 2019; Ireland et al., 2018; Kang et al., 2019; McGee, 2020; Sengupta, 2020). STEM classrooms often take on the "white is the norm" (Archer, Dewitt & Osborne, 2015, p. 1) narrative that fosters feelings of otherness for marginalized students (Ireland et al., 2018; McGee, 2020). Black and Indigenous students report feeling like they do not belong in the world of science more often than their white peers (McGee, 2020). What is more, teachers are found to play a key role in constraining Black students' ability to create STEM identities (Ireland et al., 2018). Stereotypes and biases are differentiated amongst ethnic groups but prevail in Black students (George, Maier & Robson, 2020; King & Pringle, 2019). Black students often feel alienated by STEM culture because they are forced to assimilate into a community that demands them to work twice as hard to achieve and succeed at the same level as their white peers (King & Pringle, 2019; McGee, 2020; McGee & Bentley, 2017). To fit into this narrative, underrepresented students must act tactically to limit themselves and adhere to the classroom's traditional behaviours (Takeuchi & Dadkhahfard, 2019). For BIPOC students, identity work can be rigorous, extensive, and profound, requiring discussion to account for parts of their identities that do not fit into these STEM norms (Ireland et al., 2018; McGee, 2020).

In addition to race, gender, and class, queer identities are also marginalized within STEM, as queer bodies are not often seen as being a part of mainstream STEM identities. One of the tenets of queer theory advises against "the heterosexual bribe," which refers to the cultural rewards of those whose public expression of self and behaviours fit into a stereotypical heterosexual identity (Takeuchi & Dadkhahfard, 2019). The combination of queer theory and ideas surrounding pedagogy and curriculum broadens knowledge beyond sexuality and demonstrates the varying processes of perception, cognition, and interpretation related to education (Takeuchi & Dadkhahfard, 2019). The inclusion of queer theory to teaching and learning practices illuminates how power takes over different learner bodies within the social body in which power is exercised. Power is used to oppress bodies that are outside normative boundaries. When queer bodies engage in STEM, they challenge normative standards. Knowledge of these dispositions can enlarge EDIA possibilities for all students in STEM through representation, participation, and meaningful discourse.

STEM education is often treated as politically neutral and viewed as a single entity that is free of cultural and gender-related influences despite the inherently political discourse surrounding it, which values objectivity and certain bodies more than others (Bang, Marin & Medin, 2018; Das & Adams, 2019). The focus of STEM education should be on the cultural and historical nature of learner bodies as these are, in appropriate contexts, indicative of ongoing becomings (Takeuchi & Dadkhahfard, 2019). Rethinking learner bodies challenges the traditional framework of teaching and learning in STEM. The world of education, from humans to curriculum, needs to consider bodies as simultaneously cultural, historical, and political as, for some, their bodies are forced to be hidden or restricted in order to assimilate into the public space of learning (Ireland et al., 2018; King & Pringle, 2019). BIPOC perspectives in relation to teaching and learning should be taught to all students, to ensure that there is no tokenization. In addition, inclusion should be fostered in the classroom and not single out students.

4.7 Education Policy and Structures Strengths

Schools that actively focus on being inclusive generally become the most effective in combating discrimination, embracing and welcoming diversity, and building an inclusive sense of community while providing education for all students (Whitley & Hollweck, 2020). Previously, when creating inclusion policies, the focus was on students with exceptionalities, students with special education needs, French language students, and Indigenous students (George, Maier & Robson, 2020). However, more recently, policymakers attempt to focus on students who have been marginalized throughout history and those who have been failed by current education systems (Ibe et al., 2018; Takeuchi et al., 2020; Whitley & Hollweck, 2020). The implementation of these new policies aims to identify and dismantle the systemic barriers that hinder intersectional students’ successes and design education systems that is inclusive of communities and students alike.

4.8 Education Policy and Structures Gaps

Structural racism in education continues to impact diversity and enrollment growth in STEM (Cooper, 2020; McGee, 2020), which in turn affects diversity in the landscape of the digital economy. The structure of traditional education systems has been built on Eurocentric ideologies that have a history of white male supremacy, a culture of survival of the fittest, and racial stereotypes that devalue underrepresented students’ intellectual contributions (George, Maier & Robson, 2020; McGee, 2020; McGee & Bentley, 2017). These structures contribute to the continued systemic barriers that stand in the way of the success of underrepresented students. These dispositions are also often related to: social inequality and inequity, inadequate resources, Eurocentric-focused curricula, low expectations of teachers towards socially marginalized students, and a lack of resources in rural schools (Cooper, 2020). This structural racism creates environments that contribute to negative experiences of underrepresented students. It is in these harmful environments that students feel more stress and self-doubt, question their abilities, experience academic performance anxiety, and question where they fit in in the world of STEM (McGee, 2020; McGee & Bentley, 2017). To increase diverse representation in STEM careers, education systems must become more equitable and inclusive in terms of race, gender, culture, and socio-economic background–creating environments that attract more diverse student participation in STEM courses in the K-12 and post-secondary education systems (Canada 2067, 2018a; Lee, 2015). To attract and retain underrepresented students in STEM, structural racism needs to be seriously addressed, including factors such as power, privilege, and institutional barriers created through policies, practices, and procedures that continue to promote discriminatory actions and affect educational choices (Ireland et al., 2018; McGee, 2020; McGee & Bentley, 2017).

When examining the impact of structural racism on student persistence in STEM education and careers, the “leaking pipeline” analogy (McGee, 2020, p. 633) has effectively described how underrepresented students gradually leak out of the STEM education system, resulting in a lack of diversity in STEM careers (McGee, 2020). To address this leaky pipeline, educators need to address why this pipeline does not leak for white students– first by addressing the harmful role of anti-inclusive design and structural racism in education. Research also indicates a gap in assessing the impact, successes, and challenges of programs and changes made with the goal of supporting and improving the retention of underrepresented students (Cooper, 2020; Wiseman, Glanfield & Lunney Borden, 2017). Future research needs to focus on where underrepresented students leave STEM and include the role of high school guidance counsellors, standardized tests, high school algebra, gifted programs, advanced placement, and diversity of STEM teachers (Lee, 2015; McGee, 2020).

Recent research on educational policy in British Columbia and Ontario has revealed that when education ministries prioritize the academic well-being of certain groups (in this case, French language, special education students, and Indigenous students in British Columbia specifically) through adequate funding and resources, along with clear, unambiguous policies and training, there is a measurable increase in the success and opportunities offered to students (George, Maier & Robson, 2020). The assumption is that if similar attention is paid to race and intersectionality, the material results themselves will be similar (George, Maier & Robson, 2020). For these approaches to be successful, teachers need to recognize historical and structural barriers to access in their schools and classrooms. In many cases, teachers and school staff who hold a different social identity than their students often find it difficult to fully understand the challenges that underrepresented groups face (Ibe et al., 2018). This reality highlights the importance for teachers and school staff to spend time finding ways to be representative and inclusive of the student population, from kindergarten to high school. This requires, among other strategies, a change in hiring policies, as well as recruitment and training for future teachers. While cluster diversity hires have proven to be increasingly popular in higher education, we must note how new faculty need to be supported once starting—and not be tasked with tokenizing work such as overemphasizing EDIA committee work. These realities must be taken into consideration in K-12 hiring policies.

With a focus on the importance of EDIA over the past few years in Canada, there have been various new policies and positions added to Canadian education systems. However, with the incorporation of these new policies, there also seems to be some confusion surrounding where responsibilities lie in regard to supporting student success. Some teachers find that the new positions lack clarity and communication in relation to some of the other existing positions, causing an overlap of tasks. This can be seen as a barrier in creating effective support for students since a confusion of responsibilities between educators and support staff could result in student needs failing to be addressed, as well as services being overlapped (George, Maier & Robson, 2020; Whitley & Hollweck, 2020).

While inclusive policy change is continuing to emerge in Canada, the need for inclusion of underrepresented students remains urgent. BIPOC and 2SLGBTQ+ students face pervasive systemic barriers encountered within structured school systems through curriculum and policies. This is heightened by a lack of training in schooling systems as it pertains to EDIA measures, a lack of availability of substitute teachers needed to take over a classroom while full-time teachers attend in-service training and learning opportunities. We must add that while useful, professional development opportunities being held after school hours are not ideal as they do not contribute to healthy work-life balance. Canadian school staff need to continue to make meaningful change in the roles that school policies and procedures play in terms of creating barriers to learning, creating processes that include students and communities in decision-making related to policies and procedures that involve and impact them.

4.9 Community Support Strengths

As Canada embraces inclusive practices that enhance learning and retention of diverse learners in STEM education and careers, cultural relevance and representation remains crucial in helping shape students' perceptions of knowledge–meaning that, if a lesson is perceived as particularly empowering to students, it will allow them to feel that they can apply it to their lives and their communities. In these environments, students are more likely to be engaged and therefore welcome further information and skills related to the previous information (Bouillion & Gomez, 2001 as cited in DeFelice et al., 2014). Students tend to consider STEM useful when applied to their lives by helping them solve problems, making their lives easier, or validating their interests as they related to their culture (DeFelice et al., 2014). A need emerges then for more relevant and community-based education practices.

Community-based education works to engage students and allow them to foster a deeper meaning towards STEM and STEM-related disciplines. This approach aims to reconnect education with the well-being of community life (DeFelice et al., 2014). This idea is critical because schools are "in communities, but not of the communities" (Bouillon and Gomez, 2001, p. 878 as cited in DeFelice et al., 2014). Place-based education is related to community-based education in that it works to deconstruct the barriers between schools and communities (DeFelice et al., 2014; Goodnough & Galway, 2019; Sutherland & Swayze, 2012). Place-based education allows for education standards and curriculum to be more meaningful and relevant to students by encouraging teachers to incorporate local resources relevant to what they encounter daily and relate that to STEM content and transdisciplinary concepts.

4.10 Community Support Gaps

Support systems are critical in increasing the advancement and retention of underrepresented students in STEM (Cooper, 2020; McGee, 2020). Support systems such as family, Elders, teachers and support staff, peers, mentors, and community networks can provide positive role models that support the development of STEM identities and nurture confidence within the classroom. This sense of community and connection is reported to positively impact persistence and success rates of underrepresented students in STEM (Cooper, 2020; Fernandez, 2021; Ireland et al., 2018; McGee, 2020; Parker, Pelletier & Croft, 2015). Research highlights the need for role models and teachers to reflect diverse lived experiences, including same-race and/or same-gender identities (Castek, Hagerman & Woodard, 2019; Cooper, 2020; Cross-Francis et al., 2019; McGee, 2020; Parker, Pelletier & Croft, 2015). When mentors are not of the same-race or gender, and have not participated in meaningful training, there is a risk of inappropriate recognition of students' identities. Instead, the relationship may focus on fixing or helping students conform or assimilate into the dominant white and cisgender culture (Castek, Hagerman & Woodard, 2019; McGee, 2020). Mentors need to be prepared by having an awareness of their own privileges and intersectionalities (if this is the case), the role and history of discrimination in the lives of the students they are working with, and the community's cultural and professional expectations (Castek, Hagerman & Woodard, 2019). Diverse STEM role models are also crucial in STEM identity development as students have identified the need for role models that are representative of their own identities (Ireland et al., 2018).

Family support has also been identified as critical in promoting and supporting students in pursuing studies and STEM careers (Ireland et al., 2018). Parents are vital in increasing enrollment and retention in STEM courses. Indigenous students have identified family and support from friends as the most critical factors for their success (Cooper, 2020; Ishimaru, Barajas-López & Bang, 2015). Thus, parents need to be supported, be invited to participate in the school environment, and be provided resources to better understand STEM opportunities—the ultimate goal being to increase access to, and diminish stereotypes and biases about who belongs in, STEM careers (Canada 2067, 2018a; Lee, 2015; Parker, Pelletier, & Croft, 2015). To further emphasize the importance of home support, studies show that positive attitudes at home related to STEM encourage student participation and persistence. Ireland et al. (2018) noted that when parents have high expectations in math, Black girls' math confidence is positively impacted. Increased confidence directly impacts STEM identity and achievement of learning outcomes. Parents also need to be supported to provide opportunities for young people to learn about and become interested in STEM at home, especially as students reach high school, where learning opportunities at home tend to decline (Canada 2067, 2018a; Ireland et al., 2018).

Indigenous students have also identified associations and support services as necessary in supporting their success (Cooper, 2020). These services are beneficial when providing support and guidance that includes academic, financial, mental health, wellness, and cultural resources (Cooper, 2020). Community partnerships between schools, teachers, museums, and universities can help build community support for STEM interests in underrepresented groups. The implementation of family and community-based engagement allows STEM educators to reach the "untapped" sources of familial expertise which include cultural resources, lived experience, leadership, and political power (Ishimaru, Barajas-López & Bang, 2015).

There is also a call for more classroom support. That is, educators cannot teach all students alone but need support from other teachers and professionals directly to identify and incorporate EDIA practices in their classroom. For some teachers, being alone in the classroom with students is traditionally how classes have run. Therefore, for teachers to be open to having others in their classroom, there needs to be a significant shift in mindset that needs to happen (Whitley & Hollweck, 2020). This idea of collaboration may involve teaching staff in varying disciplines and areas of expertise due to the transdisciplinary nature of STEM.

The changes required to transform the K-12 STEM education system to one that is inclusive and representative of the diverse communities they serve cannot be done alone by school administration and educators, let alone by students. The gap between the current Eurocentric approach to STEM teaching and learning and an inclusive education system must be closed by including communities and individuals in decision-making. To transform Canada's K-12 education system to generate a more diverse and inclusive digital workforce, there is a need for continued commitment to developing relationships between school and community as collaborative versus consultative (Wiseman, Glanfield & Lunney Borden, 2017).

5. Implications

5.1 Policy

Structural racism remains a key factor in the lack of diversity, enrollment, and persistence in STEM education (Cooper, 2020; McGee, 2020). Many facets of the educational system, including class size, teacher education and training, curricular content, graduation requirements, and the extent of inclusion and representation present within schools, are governed by policymakers, among other governing bodies. Though different provinces, regions and individual schools have differing policies, many of these policies continue to be built on Eurocentric ideologies that uphold white male supremacy and heterocentric ways of being/knowing/doing. Systemic barriers that stand in the way of underrepresented students and their academic success are sustained due to the role of white power and privilege, which must be addressed before creating and implementing any new policies (Ireland et al., 2018; McGee, 2020; McGee & Bentley, 2017). Educational policy reform needs first to address these barriers that marginalize students in STEM and secondly prioritize the academic well-being of these students. Research has suggested that in British Columbia and Ontario, when educational bodies prioritize the academic well-being of underepresented groups through adequate funding, clear and unambiguous policies, effective teacher training and adequate resources, there have been significant increases in student success (George, Maier & Robson, 2020).

When teaching and learning is catered to one specific identity more so than others, stress, self-doubt, feelings of otherness, and negative experiences and emotions are increased in students. Policymakers and policies need to move towards EDIA standards to create an environment that attracts more diverse bodies to STEM education (Canada 2067, 2018a; Lee, 2015). The current educational policies and policymakers need to take on a framework that strives to embrace the complexities that come with reducing educational disparities and acknowledging the various ways in which barriers against various identities manifest in schools before making any decisions that pertain to students and provincial curricula.

Education policies need to address EDIA measures in funding, resources, curricula, inclusive pedagogies, staff, support staff and hiring policies. Ideally, these policies should align with EDIA measures we would like to see in other government policies such as housing, welfare, drug abuse programs, mental illness programming, and resources and health care. These policies need to prioritize links between schools and communities so that students can better connect and see themselves in STEM education—creating STEM identities that critical scholars describe (Adams et al., 2018; Cross-Francis et al., 2019). However, school staff, including teachers, principals, support staff, and administration, must be aware and cognizant of the structural barriers present within their schools and classrooms. Teachers and school staff need to attend to these realities so that students relate to and feel supported by their schools (Ibe et al., 2018). Identifying and dismantling the many barriers present within the schooling system must be a rigorous exercise, especially when one considers the various facets of intersectionality that go along with underrepresented identities.

5.2 Practice

The continued need for STEM curriculum reform in Canada calls for an inclusive school system that is accessible for all Canadians and its ability to include underrepresented students in the future of the digital economy. The importance of curriculum reform is demonstrated in the continued efforts to improve STEM inclusion with increases in post-secondary enrollments and positive attitudes towards STEM careers (BC Ministry of Education, 2016; Cooper, 2020; NB Department of Education and Early Childhood Development, 2016; Ont. Ministry of Education, 2020; Province of Nova Scotia, 2016). Over the past years, there has been an emphasis on STEM and digital literacy in Canada, and now is the time to focus on the needs and representations of underrepresented groups like women, gender-diverse individuals, and BIPOC groups (Cooper, 2020; Innovation, Science and Economic Development Canada, 2017). Despite this focus, multiple studies have demonstrated how white men constitute most computer programming university graduates (Frank, 2019; Wall, 2019). In parallel, many studies have called for more critical counterbalancing of girls in STEM disciplines (Gosling & Gonsalves, 2020; Habig, Gupta, Levine & Adams, 2020; Lemieux & Rowsell, 2021; Sengupta, Shanahan & Kim, 2019; Thomas, Howard & Shaffer, 2019). Research has identified that underrepresented students continue to leave STEM throughout their K-12 education, leaving them without the requirements needed to enter post-secondary programs and secure a career in STEM fields (Cooper, 2020; McGee, 2020). A continued focus on transforming STEM curricula through the adoption of culturally responsive and constructivist pedagogies that integrate real-world, hands-on learning that is informed by local cultures, languages, and values will positively impact student engagement, belonging, learning, and persistence in STEM studies and career pursuits.

Curriculum reform that reflects changes to educational pedagogies will directly impact teaching practices and professional development requirements for teachers and support staff. Adopting culturally responsive and constructivist pedagogies will require developing and adopting new knowledge skills, attitudes, and changes to teaching and professional practices. School administration will be required to plan for adequate time for professional development (ideally in teachers' regular schedules with paid periods), considering the needs of both pre-service and in-service teachers, implementation of inclusive practices, and assessment of successes and challenges.

The traditionally Eurocentric approach found in STEM learning environments continues to perpetuate that white is the norm, which devalues underrepresented students' contributions (Archer, Dewitt & Osborne, 2015; McGee, 2020). These environments negatively impact underrepresented students by causing them to question their belonging, doubt their ability to contribute to STEM fields, and severely harm feelings of belonging in STEM (McGee, 2020; McGee & Bentley, 2017). These stereotypes impact teachers, parents, and professionals' perceptions of who belongs in STEM education and continues to create barriers for underrepresented students who are often pushed outside of STEM careers. Teachers and administrators can positively impact student retention and success by putting in place student-centered and culturally-attuned learning environments where norms are challenged, STEM identities are developed and respected, and individualities are celebrated rather than silenced.

5.3 Research

While our review of available literature has highlighted many curricular, training, and policy changes that should be considered in the development of EDIA practices in STEM and digital literacy curricula across Canada, we have also highlighted several gaps the literature. There is a need to pursue research on intersectionality in education, particularly in coding and STEM. Although many studies and research articles focused on aspects of underrepresentation such as the experience of girls, neurodivergent, Indigenous, and Black students—with a few specifically targeting Black and Indigenous girls—there were few articles that address intersectional identities fully. While the work that has been done on Indigenous and Black students is essential and central to EDIA practices, students from all underrepresented backgrounds would benefit from intersectional research that further looks at the educational impact of all genders and race, in combination with structural marginalizing factors such as household income and finances, school funding attribution, citizenship and immigration status, access to resources, accessibility, parental education, and linguistic barriers.

6. Conclusion

This knowledge synthesis review points to thematic areas that ought to be investigated further to address intersectionalities in K-12 education systems across Canada. One can acknowledge that many systemic barriers in Canadian schooling systems that marginalize students remain, further contributing to the underrepresentation of BIPOC and 2SLGTQ+ students in STEM education. A substantial amount of research has focused on the lack of diversity in STEM careers. There are also substantive spaces that we think need to be created, as opposed to integrated, for BIPOC students, girls, students whose first language is not English, and students whose sexuality is diverse if Canada is serious about creating an EDIA landscape for future employment in the digital economy. Important studies have maintained how Eurocentric ideologies predominate in STEM, thus marginalizing BIPOC and 2SLGBTQ+ students. Structural racism and societal hierarchies continue to impact diversity, enrollment, and persistence in K-12 STEM curricula. Educational policy must be examined to address the role of power and privilege in its structure and beyond, while prioritizing spaces to nurture underrepresented students' well-being and success. It is crucial that EDIA policies in Canada address the need for funding, resources, curriculum development, inclusive pedagogies, professional development, support roles and diverse hiring to ensure impactful change.

Curriculum and structural changes need to address, or continue addressing, how project-based and hands-on learning in STEM considers EDIA in its pedagogical activities—much of the research we reviewed pointed to curricula that is enhanced by being informed by diverse cultures, languages, and values. One question that is often asked relates to responsibility, and the ways in which schools might ensure that teachers are taking the necessary steps to create a culturally relevant learning environment. The answer to this question remains complex and stratified within structural systems, and studies are clear that a first step is to support long-term professional development, where teachers and administrators take ownership and responsibility of their beliefs, values, privileges, and work towards the adoption of meaningful EDIA principles in their schools. Schooling systems also need to be held responsible for taking the initiative to address these issues and support necessary professional development (George, Maier & Robson, 2020). The introduction of mandatory EDIA training for all teachers—in which teachers would be called to self-reflect and learn about the various and most effective ways of making a classroom inclusive—would allow students, parents, communities, and teachers alike to work towards creating meaningful opportunities for marginalized students in STEM. This professional development can support continued evolution of teaching practices grounded in teaching that focuses on race, gender, and Indigenous ways of knowing, for example. EDIA orientations influence greatly how we interpret, perceive, and explain concepts and ideas. This is important to keep in mind with regards to schooling systems as they prepare teachers to help students build systems of knowledge (Bang, Marin & Medin, 2018). Consideration must be given to professional development needs for both in-service and pre-service teachers to ensure all teachers are prepared and informed on how to create classrooms where students feel welcome and that they belong. This is imperative as it impacts student retention and success, which in turn has repercussions on college enrolment and career opportunities (McGee, 2020). When teachers and support staff are prepared to create supportive STEM learning environments, underrepresented students will have more opportunities to develop a sense of belonging, their learning will be enhanced, and their retention and persistence rates will improve (Ireland et al., 2018; Cooper, 2020).

Support systems are often critical in increasing persistence for underrepresented students in STEM. Families of students need to be better supported by schools through support services such as community partnerships that provide academic, financial, cultural, and mental health and wellness resources. By including student voices, families, Elders, and communities into schooling, students can be provided with opportunities to be involved with STEM outside of school. By involving diverse supports and knowledges, skills, values, cultures, and traditions into teaching and learning spaces, the understanding of STEM and STEM identities can be further democratized as school decision-making should center students and families to engage in STEM education. This support network might provide positive role models for students, help foster a sense of belonging in STEM fields, and help students feel more welcome within STEM. However, for students to be able to see themselves in STEM, schools also need to have diverse teachers, role models, and support staff present within schools. Diversity amongst school staff is important because adults in charge reflect diverse lived experiences to which students can relate. To generate more inclusive, diverse, and equitable futures for STEM learners, school administrators, teachers, support staff, and communities must transform learning environments to include and represent diverse student bodies and value community knowledge and histories. Provincial educational policies and the related stratified systems in which education takes place must dismantle the white heteronormative discourse in STEM learning environments. This change includes a raised awareness followed by active measures for teachers, parents, and professionals to generate environments that reflect who STEM learners are and what they can accomplish.

Our review of the literature pointed to findings that show how teachers who hold different social identities than their students often find it difficult to understand the extent to which underrepresented groups face systemic barriers. BIPOC students often feel like they cannot engage with STEM identities because they do see themselves corresponding to the traditional identity of how a scientist looks, behaves, and presents themselves, causing them to feel alienated from STEM education and careers (King & Pringle, 2019). Middle school is a vital time for students to engage in meaningful learning activities that might forge their later areas of interest, and research points to the need to continue to conduct similar studies that advance findings on the impact of middle school education on future careers, especially in a digital economy landscape. Another important factor identified in creating inclusive learning environments includes the addition of supports in the classroom so that teachers can feel supported in their work. This method requires support teachers, resource teachers, and administrators to collaboratively identify the resources that reflect EDIA measures efficiently. A continued focus on inclusive learning environments helps create spaces where students can develop STEM identities, build self-efficacy, feel like they belong, and feel valued for their contributions and experiences. Patterns in various articles explored in this synthesis review have pointed to students' desire to live and study in a school environment where they are happy, supported, encouraged, and inspired—so as to have rich interactions with their teachers and peers and be engaged in their own learning. EDIA environments cannot be created without addressing the barriers that prevent students from feeling supported, encouraged, and inspired to succeed and pursue their education, especially in STEM. To ensure success in curriculum and policy reform that is reflective of and values the diversity of the communities it serves, school decision-makers must seriously consider the realities of students, families, and community members that contribute to and engage in STEM education. School decision-makers must collaborate with all community stakeholders to design and deliver meaningful curricula that support and validate students, families, communities, values, traditions, and cultures.

6.1 Future Research

The reviewed research provides policy considerations for EDIA; however, there is still work to be done to reflect the broad view and underlying complexities that affect students and the way they are treated in provincial schooling systems. In identifying and highlighting the gaps between the problems and current approaches, policymakers need to adopt a deeper and broader understanding of the problems to widen the spectrum of possible solutions to improve EDIA within schooling systems. Without a greater willingness to research and investigate various aspects of harmful systems before policies are created are even implemented, progress in addressing systemic barriers will be slow and prolonged.

As part of this work, research needs to encompass intersectionality in education, and particularly in coding, STEM, and more largely in digital literacies—as student identities are representative of many different identities that relate to intersecting dispositions (Adams et al., 2018; Fernandez, 2021; George, Maier & Robson, 2020; Ireland et al., 2018; King & Pringle, 2019). Many studies and research articles focus on the experience of girls, neurodivergent, Indigenous, and Black students—and this research needs to continue being funded and supported by governing bodies and educational institutions. Focusing on intersectional identities, student wellbeing, and learning environments is useful for the future of the digital economy. Enhancing the development of EDIA policies based on intersectional research ay prove promising towards the broader and more inclusive vision that Canadian provinces promise.

Over the past years, much work has been undertaken across Canada on development and delivery of initiatives and programs to support underrepresented learners for success in STEM education and careers. These studies are important to continue to develop inclusive practices that encourage equitable, diverse, and inclusive futures in future digital professions. Considering that digital literacies and coding are a priority for provincial governments, research will need to continue being funded and conducted in Canada on the development of digital literacies in schools considering EDIA measures.

7. Knowledge Mobilization Activities

The research team's knowledge mobilization plan develops two axes: (1) outreach to key stakeholders, such as community and government, through public research report writing and related report presentation (September 2021), and (2) dissemination of the synthesis literature review in peer-reviewed open-access research journals.

Phase 1 ran from January to September2021 and focus on Axis 1, i.e., preparing the report in time for the co-presentation at the September 2021 Ottawa Forum. The PI trained graduate and undergraduate students in report writing and presentation, an important skill development activity, thus developing essential knowledge mobilization skills. Preparing these outcomes, the PI and research assistants explored a variety of sources and documents (such as academic literature, government reports, and provincial and territorial curricula), and reached out to key researchers and community stakeholders with established relationships. The study of these essential community relationships shaped the relational dimensions of the outcomes, as it pertains to what is done in practice and how it aligns with the research synthesis. Undergraduate and graduate students played a central role in this research and source analysis, identifying the gaps and strengths in current educational programming and literature, in order to determine—under supervision of the PI—the implications of the review on future educational endeavours. This helped develop students' writing and analytical skills while allowing them to discern real-life implications of their work. Students assisted the PI in liaising with key figures, organizations, and regulatory bodies in the final stages of the report, to verify the content and the conclusions of the review against actual currents and truths within education, STEM, and intersectionality advocates. This initiative nurtured students' networking skills and created effective working relationships with key stakeholder in the applied world. Simmonds and Boyle joined Lemieux in presenting virtually the findings at the SSHRC Forum in September 2021, as part of SSHRC's guidelines for this call.

Phase 2 will run from Fall 2021 to Fall 2023 and will focus on the second subsequent axis, i.e., co-writing for publication. The PI will train undergraduate and graduate students in designing and co-writing a review article. A portion of significant results will be first published in English and submitted to an open access journal known for publishing review articles in educational technology and education more broadly. We will review the possible journals in late 2021. These include: the *Canadian Journal of*

Education, the *Canadian Journal of Learning and Technology*, the *Journal of Curriculum Theorizing,* and *Teaching & Learning Inquiry*. The first step of working towards co-publication will consist of articulating the challenges and gaps emerging from the synthesis review in ways that are suitable and relevant for a review article. Related media outreach will ensue 2022, as well as the projected French translation of the report, undertaken by a graduate student trained in translation studies and with expertise in education. This work will be supervised by the PI.

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Appendix 1: List of Abbreviations

BIPOC: Black, Indigenous, and People of Colour
EDIA: Equity, Diversity, Inclusion, and Accessibility
ICT: Information and Communications Technologies
POC: People of Colour
STEM: Science, Technology, Engineering, Mathematics
TPACK: Technological Pedagogical Content Knowledge

Appendix 2: Definitions

The research team was inspired by the definitions from the following studies.

Accessibility: The attribute that makes something within reach, capable of being reached, seen, understood, and appreciated by all, including those with disabilities (Merriam-Webster, n.d.).

Culturally Responsive Pedagogy: "[A] pedagogical approach that is centered on the cultural identity of students, particularly the cultural resources they bring into the classroom from their community'" (Cooper, 2020, p. 3).

Diversity: "[R]efers to the inclusion of different types of people" (Adams et al., 2018, p. 9).

Double Bind: "Refers to the exclusion of women of color in STEM and the undermining of their career pursuits because of both racism and sexism" (Ireland et al., 2018, p. 228).

Equity: The concept through which science education takes into account power, culture, epistemology, and identity in order to increase participation, achievement, and access across all identity groups (Adams et al., 2018).

Gender: An identity category that includes male and female, but also goes beyond this binary to include trans, genderqueer, and gender variant identities (Parker, Pelletier, & Croft, 2015, p. 1).

Inclusion: "To be fully inclusive, addressing who a maker is, what a maker makes, why a maker makes, what kinds of access a maker has to tools and opportunities to keep making, and how making has historically featured in different cultures is all a part of inclusion" (Castek, Hagerman & Woodard, 2019, p. 15).

Inquiry-Based Learning: A form of learning that "is best accomplished using more student-centered active-learning strategies" and focuses on the use of "scientific knowledge to solve problems" (Gormally et al., 2009, p. 1).

Interdisciplinarity: A form of learning that integrates knowledge and methods from two or more disciplines in a harmonious way, while looking at all involved disciplines as a coherent whole (Choi & Pak, 2006).

Integrated STEM: "[T]he concurrent teaching of two or more knowledge silos that constitute STEM school subjects" (Davis, Chandra, & Bellocchi, 2019 p. 24).

Intersectionality: A theoretical position that promotes a deeper understanding of the multi-dimensionality inherent in racial exclusion and discrimination. All identities and social categories to which an individual belongs have consequences on that individual's life, and often affect each other differently based on context (Bruning, Bystydzienski & Eisenhart, 2015; Ireland et al., 2018; Sengupta, 2020).

Multidisciplinarity: A form of learning that utilizes the knowledge from two or more disciplines to solve a problem in another discipline. This approach has little interaction across disciplines and uses new knowledge and perspectives in an additive manner (Choi & Pak, 2006).

Problem-Based Learning: "[P]osits that learning experiences should be learner-centered, integrate theory and practice, and require students to conduct research and apply knowledge to solve ill-structured problems" (Noble et al., 2020, p. 3).

Race: "[A]n ideological construction that has social ramifications for how power is structured in our society, which informs the use of biological and cultural factors to determine a group's supposed attributes, or lack thereof. Everyday racism also views race as structural because of the dominance along racial and ethnic lines that is widely reproduced through [...] laws, policies, regulations, and rules that are based on philosophically inequitable principles" (McGee, 2020, p. 634).

STEM Identity: "[I]s a general form of occupational identity, defined as an individual's personal identification with or relation to a specific career or academic pursuit in science, technology, engineering, or mathematics" (Ireland et al., 2018, p. 248).

Transdisciplinarity: "Transdisciplinarity [...] draws on a number of works contesting the created, reproduced, and hegemonic boundaries of disciplines" (Das & Adams, 2019, p. 292).