Equity, Diversity, and Inclusivity at the Intersection of STEM and Business Management in Canadian Higher Education

Final Report

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Executive Summary

This research initiative is focused on an empirical study with respect to the Concordia University's summer institute, "*Equity, Diversity and Inclusion (EDI) in science, technology, engineering, and mathematics (STEM)*". This study's objective is to contribute to expanding our understanding of EDI at the intersection of STEM/Business Management in higher education.

In this report, we present a background to this summer institute, a literature review and our methodology. We also present our empirical findings and analysis of a survey administered to participants in the summer institute, and the results of two semi-structured interviews.

Our eight recommendations are built on the literature review, and on these empirical findings and results. They also reflect the limitations of our study which is our small sample size. The top three recommendations include building intentionality with respect to EDI, lobbying and seeking funding to build such a framework of EDI in higher education institutions, and inviting industry representatives and persons in power to speak to EDI concerns at this intersection. Future work in this particular area is also considered, such as a follow on study with a larger sample size, and closes this report.

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Introduction

There is increasing concern that the demographic imbalance in STEM education will affect Canada's competitiveness in the global marketplace (Catalyst, 2013; Drew, 2011). We also recognize that the Canadian Federation of Business School Deans (CFBSD), its members and various stakeholders in the Canadian Business Management education sector acknowledge their responsibilities with respect to drawing attention to the need for expanded education in developing business and management skills when it comes to science, technology, engineering and mathematics (STEM) concerns. The study of equity, diversity and inclusion (EDI) at the intersection of STEM and Business Management in higher education is one avenue into a conversation about this intersection. This study looks to add to this conversation by providing an evidence-based approach to the study of EDI at the intersection of STEM and Business Management in higher education.

To this end, we conducted an investigation into the impact of the Concordia University Interdisciplinary Summer Institute (CUISI) 2019, titled "*Equity, Diversity and Inclusion in science, technology, engineering, and mathematics: Achieving research excellence by adopting new perspectives*"[1]. This summer institute was initiated by Dr. Tanja Tajmel, the responsible institute leader, and subsequently organized and led together with Dr. Stefanie Ruel, and realized in the framework of the School of Graduate Studies. With this summer institute, we invited graduate students to work on achieving EDI-principled outcomes in an integrated STEM and Business Management platform. The question we set out to answer is: "how can business education and STEM education work together with respect to social considerations, such as gender/race/ethnicity/etc., and social equity and inclusivity, within the Canadian higher education system?" Our research objective is to contribute to our knowledge of EDI at the intersection of STEM and Business Management via an evidence-based study of this summer institute and to propose structural educational, pedagogical and social outcomes to the CFBSD. The educational and pedagogical considerations include a presentation of the summer institute learning objectives, while the social outcomes include the impact of social equity and inclusivity course on graduate students.

Data collected from participants of the summer institute include a survey instrument and semi-structured interviews. This was complemented by an autoethnography by each of the two leaders of this summer institute, Dr. Tajmel and Dr. Ruel and a statement from each of the two undergraduate students, one from STEM and the other from Business Management, who participated in this funded research. These data are analyzed in such a way to add to our understanding of EDI at the intersection of STEM and Business Management.

This report is presented to add value to the decision making of the CFBSD, its members and various stakeholders in the Canadian Business Management education sector. This report supports the CFBSD's overall mission to expand the organization's knowledge and

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[1] This summer institute can be viewed online: https://www.concordia.ca/sgs/summer-institute.html

understanding of this issue by suggesting an EDI framework, via our pedagogical and research approaches. Our recommendations, stemming from the empirical study, focus on areas of improvement for structural educational, pedagogical and social outcomes, in the particular context of the EDI intersection of STEM and Business Management higher education.

Summer Institute Background Information

As the coordinators and professors of the summer institute, that took place in May 2019, we drew on our respective research agendas, our teaching philosophies, and on our diverse global academic and practitioner networks to coordinate and present this summer institute. This summer institute provided an interesting opportunity to study *in situ* the EDI concerns at this intersection. We invited graduate students to work on achieving EDI-principled outcomes in an integrated STEM/Business Management platform in higher education. To our knowledge, no one to date has attempted to bridge this gap and to create this type of synergy.

By inviting these graduate students to our EDI cause in this integrated, globally diverse STEM/Business Management context, we provided a vehicle to expand our knowledge towards achieving EDI principled outcomes. In other words, we modelled an EDI framework via our pedagogical and research approaches to the future generation of academic researchers and professors, inviting them to join this important conversation.

Goals, participants, and pedagogical approach

Our objectives for this summer institute was for diverse graduate students to develop collaborative skills, to develop a broader understanding of the reproduction of social inequalities in the field of STEM, to explain and discuss gender and diversity, and other relevant concepts and theories from various streams, with respect to the contexts of STEM/Business Management, and to critically evaluate technical and academic literature framed within EDI. As for the specific question of demographics, this summer institute was for anyone with an interest in learning more about EDI in the context of STEM and Business Management. This included Master's and PhD students, across different faculties, such as the Gina Cody School of Engineering, John Molson School of Business, and Faculty of Arts and Sciences.

We presented in this summer institute various topics, supported via lecture-type activities, group-work and field-work. Some of the topics that we touched on included: human rights and STEM, such as the right to STEM education, discrimination, legal frameworks; gender and STEM, such as women working in science and engineering fields, women working in the Canadian space industry, and gendered knowledge production and reproduction; diversity and STEM, including conceptualization of diversity (race, class, gender, body, etc.), learning about *Othering* (Butler, 1990) in various STEM fields, people of color in STEM contexts and embracing intersectional perspectives; and, Indigenous-based knowledge and STEM knowledge systems along with the experiences of Indigenous scientists in various fields. We specifically focused on introducing and discussing core concepts, such as gender, diversity, and intersectionality, with core objectives including equity, equality, inclusivity, human rights, etc., as well as the importance of

the historical and political contexts for understanding the dynamics of doing and living difference in working in STEM industries. We introduced these students to third and fourth wave feminism, critical race theory, postcolonialism, etc. (e.g. Bhabha, 1994; Calás & Smircich, 2006; Collins, 2009; Collins & Bilge, 2016; Dhamoon, 2015; Donald, 2012; Paludi & Helms Mills, 2013; The Combahee River Collective, 1979), and to the specific context of STEM and diversity concerns (e.g. Castro et al., 2013; Johnson, 2011; Nix & Perez-Felkner, 2019; Ruel, 2018, 2019b; Tajmel, 2019a, 2019b).

There were also a variety of pedagogical initiatives integrated into this institute, where the theories and concepts, and empirical evidence presented were practiced in hands-on, workshop frameworks along with field work. The graduate students conducted a group research project, formulating an academic report where they investigated the challenges in STEM-fields with respect to EDI in this integrated STEM and Business Management platform.

Literature Review

This literature review provides an overview of Canadian Universities involved in bridging STEM and Business Management, and in EDI at this intersection. We also consider EDI concerns in STEM literature and practitioner publications, along with funding opportunities in the recent past that address EDI at this intersection.

Background: Overview of Canadian University STEM/Business Management Programs and EDI concerns

A few universities host programs that bring STEM and business management education together. At the undergraduate level, for example, the University of Waterloo's (2019) Science and Business program, offers courses in biology, chemistry and physics melded with economics, accounting, marketing, law and entrepreneurship. Similarly, they have other undergraduate programs such as biotechnology and accountancy or economics, environment and business. The University of Toronto (2019) offers Economics and Mathematics, as a specialist degree, and Management and Information Technology, also as a specialist degree. Mount Royal University (2019) offers a minor in Innovation and Entrepreneurship, melding in technology concerns, into Bachelor of Business Administration. University of British Columbia (UBC) (2019a) combines an undergraduate degree, such as in sciences, with a Master of Management. Interestingly, this combined degree description is the only one found that addresses typical age of students (22-23 years old) as compared to age of students doing an MBA (28-30 years old) (UBC, 2019b). No other specific demographic information is provided on their website other than three profiles of recent student alumni that appear via photographs to be diverse from a gender perspective intersecting with ethnicity and with a bachelor program concentration.

Within the sphere of higher education case competitions, there is an international case competition that brings undergraduate engineering school students with commerce students

(Engineering and Commerce Case Competition (ECCC), 2019). In 2018, Canadian universities that participated in this case competition included Concordia, Ryerson, University of Manitoba, University of New Brunswick, University of Alberta, McGill, McMaster, and University of Calgary. Internationally, Trinity College Dublin, University of Vermont, American University in Cairo, Amsterdam University of Applied Sciences, and Ben-Gurion University of the Negev were represented (ECCC, 2019). The goal of this case competition is to "foster inter-disciplinary communication and collaboration before students start their professional careers" (ECCC, 2019, para. 1). It is important to underline that the case competition talks to inter-disciplinary efforts but does not address EDI concerns in its mission or goals (ECCC, 2019). McGill's Dobson Cup entrepreneurial competition features four tracks, each of which could be STEM/Business Management driven (McGill Dobson Centre for Entrepreneurship, 2019). There are prizes available that include the Faculty of Engineering and Desautels Faculty of Management driven awards. The Dobson Cup itself does not have an EDI statement, mission or vision statement. The McGill Dobson Centre for Entrepreneurship hub does, however, have such a mission statement.

At the graduate level, there is the University of Alberta's (2019) MBA and Master of Engineering, University of Regina's (2019) Engineering Management program, University of Ottawa's (2019) Master of Engineering in Engineering Management and a graduate diploma in Engineering Management, and Concordia University's new Master in Engineering with Engineering Management Option (Bowness, 2019). HEC Montreal (2019) offers a Master of Science in Informational Technology (« *expérience utilisateur en contexte d'affaires, intelligence d'affaires, transformation numérique des organisations* »). Ryerson University (2019) offers a similar program. UBC (2019b) offers a Master of Science in Business Administration, Management Information Systems specialization for individuals who hold undergraduate degrees in the natural sciences, engineering, and computer science.

Across the undergraduate and graduate programs in Canada that offer programs at the intersection of STEM with Business Management, we did not find any specific reference to equity, or diversity, or inclusion practices. Individual universities did have general statements about creating inclusive and accessible school environments, following various provincial and federal legislative requirements. General is used here in the sense that EDI concerns apply across the university.

Literature on EDI in STEM/Business Management

When we turn to the literature, academic and practitioner or mass media, we can categorize them across three broad areas: early STEM education (Pre-K - Grade 12); higher education (Undergraduate and Graduate); and, academic faculty who teach/conduct research in STEM or in Business Management fields. We are focusing on the last two categories for this report.

In these two categories, we found that when we searched for the three major concepts in education – that is, STEM, Business Management, and EDI - there were very few results. One

recent special issue yielded the most comprehensive literature across these three concepts. Waite and McDonald (2019) relying on a 2015 U.S. National Science Board report stated that "[…] an estimated 16.5 million [U.S.] college-educated individuals, including many working in sales, marketing and management, reported that their job required at least a bachelor's degree level of S&E [science and engineering] training" (p. 5). Furthermore, Waite and McDonald (2019) underline the lack of research being done on the question of STEM and Human Resource Development fields, finding only one article by Yawson (2011) that touches on educational training for the workforce and the emergence of nanotechnology. They do also refer to the lack of women and other under-represented groups in STEM (Waite & McDonald, 2019).

Akdere, Hickman and Kircher (2019) speak to the 2015 findings of Hart Research Associates that "[…] 95% of U.S. employers believe that college students should have experiences that teach them to solve problems with people holding different views than their own […] only 15% of U.S. employers believe that current college graduates are well prepared with regard to awareness of diversity outside the United States, and just 18% believe that graduates are well prepared to work with people from different backgrounds" (p. 50). Akdere *et al.* (2019) go on to suggest a competency model for STEM educators to develop STEM students' leadership skills, specifically in areas of self-directed learning, critical thinking, and interpersonal skills. Alfred, Ray & Johnson (2019) underscore the importance of "interventions promoting diversity, equity, and inclusion [that] must start in early and secondary education and continue through academia and the workplace" (p. 114). Framing their work within social capital and intersectionality scholarship, Alfred *et al.* (2019) also point out that the social environment within higher education institutions are "major social barrier[s] to women's persistence, retention, and matriculation through STEM careers" (p. 123). With respect to women and women of color in higher education, Alfred *et al.* (2019) underline that the "widespread stereotype that STEM fields are reserved for men, and women who believe the message tend to outperform and feel a lower sense of belonging" (p. 123). Women of color are "often the only one or one of two members of their racial/ethnic group in class, placing them in a token position" (Alfred et al., 2019, p. 123). They go further, focusing on the experience of women in graduate school, where "implicit and explicit gendered values become more pronounced" (Alfred et al., 2019, p. 124). Alfred *et al.* (2019), without providing a citation, refer to business ranks, where women of color only represent 3.2% of Fortune 500 executive positions and White women represent 13.4% of executive positions. This becomes important, given their social capital and intersectionality scholarship framework, as this reality demonstrates the lack of mentoring opportunities and informal network creation, and supports isolation and experiences of disconnection in the workplace. Alfred *et al.* (2019) conclude with the idea that diversity and inclusion in STEM and in STEM/Business Management is not only a government concern but also an educational, social and economic concern.

With respect to the question of entrepreneurship and STEM innovation, Warhuus & Basaiawmoit's (2014) study looks at five education programs in different Nordic nations to

surface future developments in the area of educational entrepreneurship programs. Building on research that STEM majors have a strong potential to create high-growth ventures, Warhuus & Basaiawmoit (2014) also emphasize the importance of developing entrepreneurial skills and mind-sets via education and training in spite of research showing that higher education in entrepreneurship may have a negative effect on entrepreneurial intentions. Warhuus & Basaiawmoit (2014) findings include that course descriptions are "dominated by traditional titles, content and topics. Yet, interview data reveal that this is delivered using progressive methods, and the students are often asked to apply new knowledge to ill-defined, open-ended, unpredictable situations" (Warhuus & Basaiawmoit, 2014, p. 327). This "political correct content; politically incorrect delivery" (Warhuus & Basaiawmoit, 2014, p. 327) does not however identify who is an 'informant' in the study. In other words, the diversity of program participants in the five cases presented and analyzed is not considered. They do, however, point out that there were cross-national patterns, and they recommend studying other regions to compare and contrast against the five cases. They also recommend that STEM driven faculties seek out business management support, along with outside stakeholder support, in program design and development (Warhuus & Basaiawmoit, 2014).

Ryerson University's round table (Ryerson University, 2017) hosted by MaRS Discovery district, Ryerson's Faculty of Science, and the Canadian Science Policy Centre, recommended building intentionality for EDI across the talent pipeline, supporting inclusivity, being prepared to manage conflict as a consequence of increasing diversity, holding organizations accountable for EDI in STEM and building EDI into the culture of academic and professional environments by increasing awareness and training. Interestingly, this roundtable recommended the traditional framework of the Employment Equity legislation, and added LGBTQ+ community and intersectionality of identity categories (Crenshaw, 1989, 1991). Furthermore, evidence-based information, both quantitative and qualitative data, surrounding inclusivity and diversity needs to be not only collected but disaggregated (Ryerson University, 2017). Within the higher educational sector, this roundtable recommended embedding EDI awareness into STEM-based teaching in such a way to strive for systemic change (Ryerson University, 2017). As informative and interesting as this report is, there was no talk of EDI concerns at the intersection of Business Management and STEM.

As we see the potential for change in inter-disciplinary higher education programs, we turned to the change literature to try and learn more about what could potentially await us in this goal of EDI at the intersection of STEM/Business Management. Henderson, Beach, and Finkelstein (2008) explain that their understanding of change covers "reflection, action research, diffusion of innovation, organizational culture, policy and theory" (p. 4). In their literature review, they found 114 possible articles that they grouped across a typology of individual change vs environment and structure change, and prescribed outcome vs emergent outcome. The vast majority (61%) of articles were focused on individual educators communicating good teaching interventions (that is, disseminating best practices, modifying instructor conception, providing individualized

diagnosis and support, supporting curriculum development, collaborative action research, etc.). With respect to environmental and structural changes, 14% of the articles they found emphasized developing rules, reward systems, reporting requirements (that is, system synchronicity, institutionalization of quality assurance measures, and directed incentives by Presidents, Chairs, and Deans). Only 5% of the articles found focused on developing a shared vision across departments or institutional units. In this last group are the issues of cultural change and policy development (Henderson et al., 2008). Borrego and Henderson (2014) interestingly applied this typology to tease out the underlying logic, scholarly teaching examples, and organizational transformation and development issues, including social factors and guiding beliefs and principles. We believe that this research project may fit into the literature on change initiatives at the environment and structure change level, following Henderson *et al.'s* (2008) typology. We also acknowledge that we need to look to individual change agents to enact EDI in STEM/Business Management.

Funding Opportunities Literature: U.S. and Canada
The U.S.-based National Science Foundation (NSF) offered funding to four universities to "develop and implement sustainability curricula that fuse STEM and business perspectives. The overall goal is to improve the preparation of students to address complex societal issues that require application of environmental and economic concepts" (NSF, 2019). The NSF awarded a total of $1.4 million to Bentley University (Mastantuono, 2019), Wittenburg University (Holbrook, 2019), Northern Illinois University, and the Science Education Resource Center at Carleton College, representing 24 faculty members from "diverse STEM and business disciplines" (NSF, 2019). One of their goals is to collaboratively and iteratively design modular case studies, that bring together STEM and Business perspectives. They also include reducing inequalities among its other goals, where they develop materials that help STEM and non-STEM majors understand and address social issues through their modular transdisciplinary case studies (NSF, 2019). Moreover, this project also aims at changing current faculty perspectives regarding transdisciplinary curriculums (NSF, 2019).

Canada's Minister of Science and Sport launched a pilot EDI program, building on the UK's Athena Swan program (NSERC, 2019). The Dimensions: Equity, Diversity and Inclusion Canada program "aims to address systemic barriers, particularly those experienced by members of underrepresented or disadvantaged groups, including, but not limited to women, Indigenous Peoples, persons with disabilities, members of visible minority/racialized groups, and members of LGBTQ2+ communities" (NSERC, 2019, para. 2). Universities who wish to adopt the Dimensions charter "commit to embed EDI principles in their policies, practices, action plans and culture"(NSERC, 2019, para. 3). The Minister also announced an investment of $5.3 million, as an EDI Institutional Capacity-Building Grant for small universities and colleges including Cape Breton University, Lakehead University, HEC Montreal, Royal Roads University, etc., "to support their efforts to create an inclusive climate reflecting Canada's diversity in their institutions" (NSERC, 2019, para. 4). To be clear, these grants are targeting opportunities in

research for women and underrepresented groups towards "building a vibrant, diverse and inclusive research community" (NSERC, 2019, para. 6). We are including this here as an indication of possible avenues for EDI in STEM/Business Management with respect to faculty hiring and promotion considerations.

As we introduced earlier, we set out to empirically study the Concordia summer institute focusing on EDI concerns at the intersection of STEM and Business Management in higher education. Our objective with this study is to contribute to our knowledge and understanding of EDI at this intersection via an evidence-based study in Canadian higher education. The question we set out to answer is: "how can business education and STEM education work together with respect to social considerations, such as gender/race/ethnicity/etc., and social equity and inclusivity, within the Canadian higher education system?"

Methodology

We collected primary data from graduate students who participated in the above described summer institute, data from two individuals who were involved[2] in this summer institute, and data from the two primary coordinators of this summer institute along with two undergraduate students who helped us with this funded study. We recognize at the outset that this was a convenience sample of graduate students and individuals involved in the summer institute. However, this sample provides interesting insights into subpopulations of graduate students interested in STEM/Business Management to which generalization may be possible.

The collection mechanisms consisted of: a survey instrument delivered to participants of the summer institute; semi-structured interviews with two individuals; and, an autoethnography by each of the two summer institute coordinators and a brief statement from each undergraduate student hired as part of this funded research. Ethics approval (30011383) was granted by the Concordia ethics committee in June 2019. The survey instrument was self-administered electronically. This survey instrument used different types of scales (Cooper & Schindler, 2014), with a focus on asking participants to provide feedback on the pedagogical approaches used, and on the intersection of Business Management and STEM concerns. We also measured social considerations in this instrument; that is, we constructed questions, both closed and open-ended, to measure the participants empowerment with respect to, for example, effecting change in systemic discrimination practices. We applied a variety of statistical analysis techniques on these collected data, including using an open-source software called JASP.

Our second analysis technique was centered on semi-structured interviews with two individuals involved with the summer institute. This activity was conducted in one case over video conference and the other via face-to-face interactions. Similarities and differences across these two interviews are presented, along with insights from each.

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[2] We are specifically not giving more information about these two individuals and their role in the summer institute in order to protect their identity.

Our third analysis approach is an autoethnography (e.g. Denzin, 2006; Ellis, 2004; Jones et al., 2012; Learmonth & Humphreys, 2012; Ruel, 2019a) prepared by the two coordinators of the summer institute (the authors of this report). During the work on this report, we found that our undergraduate students also developed in their learning and approaches to EDI concerns in STEM and Business Management. One student came from a STEM field and the other from a Business Management field. We asked them to individually prepare a brief statement about their experience in this research project. These autoethnographies and statements were included in our analysis to support our conclusions and to inform the formulation of our recommendations.

Findings and Analysis

Qualitative Open Answer Survey

This course allowed graduate students to explore and learn EDI principles regarding gender/race/ethnicity, social equity, and inclusivity within higher education systems. We observed during the summer institute that these graduate students were open to working together and addressing these inequities in a respectful and inclusive fashion. Survey respondents were asked to list the concepts/theories that stood out for them during this summer institute. We were able to organize these concepts into ten categories: intersectionality, Othering, identity, colonial concerns, diversity, women, human rights, Indigenous, and knowledge.

Intersectionality was the concept that was most mentioned by respondents, with 8 out of 11 respondents specifically flagging this concept and scholarship. Knowledge (epistemology) was the second most mentioned concept. All five men respondents and one woman respondent listed a concept related to knowledge, such as epistemology, bias in artificial intelligence (AI), and classification. Othering, colonial concerns, women, and Indigenous concepts were also mentioned by five respondents each. Identity had four respondents, followed by diversity and human rights with three.

Survey respondents additionally had the opportunity to share their thoughts about the summer institute and the concepts they learned. Thoughts included how the material provided by the summer institute was relatable and knowledgeable. One respondent wrote:

> *"Before the summer institute, I knew much less on how policies surrounding EDI inform the business and STEM fields. The institute's interdisciplinary approach is very important in order to find ways to identify and address social inequities built in to scientific work cultures, and it is only when there is communication between these various fields that there can be an attempt to remedy these."*

And another respondent wrote:

> *"[...] as long as we all consciously make efforts to counter these kinds of issues, progress will be made. The course gave me the knowledge and tools I need to work toward that end."*

Moreover, a few respondents recommended having an EDI course as part of their studies to increase awareness and address societal struggles:

> *"I would really like to see EDI courses as core classes in all disciplines across universities for undergrad and grad school programs."*

> *"More exposure of EDI to the business world is needed. The MBA program is a great channel to do so."*

These and other respondents expressed clear value towards the summer institute. While most respondents agreed that there is more work to be done in the area of EDI in STEM and Business Management, the summer institute was an overall positive experience for them that should be made available to all students.

Qualitative Semi-Structured Interviews

Semi-structured interviews were conducted with two STEM professional women who appear to have inspired students and taught them about gender and social inequalities in STEM fields. The names of the interviewees have been changed to protect their identities. There are some areas of overlap between these two interviews. Notably, both women acknowledge that there is consistent social inequalities within the field of STEM. Moreover, they believe these inequalities should not be left up to the people who are being marginalized to fight the battle themselves. They both recommended that the fight should be the universities' responsibility to address these problems and to take concrete, measurable action.

The first interviewee, Elizabeth Galen, graduated with an engineering degree in the 1970s:

> *"I got into that type of work because since I was a child I loved fixing up things and doing things and my parents encouraged me so it was both their encouragement and the love for fixing up things that made things happen [...] As a woman wanting to be equal to men and do exactly what they do, and be as good, if not better than what they do, made me go into that profession rather than having a role model and wanting to be like that person."*

After graduating, Elizabeth worked as an engineer in company A and later founded her own company. Elizabeth, who did not have someone to look up to, now is a role model for many young women in the STEM field.

The second interviewee, Blake Wells, also graduated with a degree in engineering. She worked abroad for five years in the aerospace industry, before returning to school and earning a PhD in a STEM field. Blake does not consider herself to be a part of STEM anymore, however, as she now is a lecturer at a university.

Neither interviewee thought much about the challenges and discrimination they faced during their education and early career. Instead, they focused on their own work and strive to do the best they can. To reiterate, it wasn't that they did not recognize the obstacles they faced, but rather that they tuned it out so as not to feel the effect on their respective abilities to achieve what they wanted.

In their experiences, men didn't appear to respect women entering the field. Elizabeth had to prove herself in order to fit in. Specifically, the men in her class didn't want to work with the women when it came to class team projects because they weren't seen as being up to par:

> *"The challenge is how you overcome [the men] and how you let them know you're as good as [them] in what you're doing […] For that, you have to work hard and prove yourself, and I strongly believe [that you still] have to do better to be considered equal […] You are not respected for who you are until they know who you really are, and your education and your experience and the type of work you have done. Without that, at first glance, they overlook your abilities."*

Even when Elizabeth demonstrated that she was good in her field, she still had to carry her status of being a woman of colour:

> *"They saw me and saw that I did a good job and then they remembered me […] But you are always a visible minority."*

Blake didn't remember any specific challenges that she may have faced. She did share with us one particular story regarding how some of her colleagues appeared to have internalized gender roles:

> *"I would say there were a couple of people in the office who definitely treated me differently because I was a woman in very obvious ways. […] There were other people in the office who I got along with fine, but I could tell that they had really internalized gender roles in their heads, and that this was the way they saw the world. Although they liked and respected me as a person and respected my work, you could still tell that they treated me differently sometimes."*

Blake shared a story with us about her supervisor who seemed to be influenced by outdated cultural ideas about women, in line with this idea of being treated differently:

> *"There was one time when an engineer who [returned to a company, after having left]. My supervisor who was also going to be the supervisor of this returning engineer had purchased this basket of candy. It is a [particular European] tradition to give [candy] to a child on their first day of school. He gave it to me and asked me to give it to [the engineer] who I barely knew [...] whereas my supervisor knew him quite well. He said that it was a woman thing, and that the mom always gives this to the kid. [...] He was oblivious to [what he was asking of me]."*

Elizabeth, on the other hand, recognizes that men are aware of these gender issues:

> *"I'm positive [men] were aware then and I assure you they are aware now. You may think they are not, [that] they do not care, but that doesn't mean they are not aware."*

Both Elizabeth and Blake recognized that as more women enter into STEM fields, stereotypes regarding their technical abilities will fade. Elizabeth in particular also believes that by addressing EDI concerns across the intersectionality of STEM and Business Management can help future students in expanding their knowledge and skills, building awareness regarding equality, diversity, and inclusion:

> *"At school, we need more combination of the two [disciplines]. For people to be leaders, these are the two abilities that have to come together. When [the STEM and Business students] are in the same courses, it pushes them together to see how each other thinks. [Plus] having these courses in your CV helps you get better jobs. The industry wants people with soft skills. If you want to become a future CEO, you have to know both."*

Blake is worried about the burden that is being placed on students in engineering when it comes to increasing diversity. She believes that the responsibility for EDI concerns needs to include people in positions of power and not just the students:

> *"I think that it's very important for engineering to change [and become more diverse], but I am also wary of putting that burden on students, especially students who are, for one reason or another, a minority within current populations of engineers. I really think it's on current engineers and engineering companies to change, and it shouldn't be a burden that's placed in [the minds of graduates] to make the change themselves. It should be on people who have power in engineering workplaces and within faculties of engineering to enact change."*

Elizabeth also believes universities should take the initiative when it comes to EDI concerns, and set an example for the rest of society.

> *"The institutions have to break the barrier. They are the torch bearers of society. If you go back hundreds of years, it's the institutions that are the foundation for change and the foundation for speaking up. It angers me that some institutions go completely the other way [...] EDI should be a part of their culture and they have to overcome the*

unconscious bias at the institutional level. Hopefully, the next generation have been faced with [EDI] so much that they can carry on thinking about it."

There are multiple ways universities can help encourage diversity and assume responsibility in this area, according to our two interviewees. Blake in particular listed a few examples for us: assigning value and funding to research that is important for communities that are traditionally underrepresented; hiring people of minority groups and women, and paying them fairly; actively funding research conducted by people who are underrepresented; and, teaching different perspectives, presenting a variety of materials in the classroom that move away from the 'traditional' and that embrace a more diverse knowledge base.

Quantitative Fixed Answer Survey

A total of eleven surveys were received from participants of the summer institute, representing a 58% response rate. Demographically speaking, six respondents were women and five were men. Three individuals self-identified as either queer or bisexual, while the rest self-identified as heterosexual. Four individuals self-identified that they were of a specific racialized or ethnicized group (race/ethnicity), while one individual preferred not to answer this question. Five self-identified as being educated and holding degrees in STEM fields. Three individuals self-identified as being educated and holding degrees in both Business Management and STEM. One individual self-identified as being educated in both STEM and Arts, while two individuals self-identified as being in neither STEM or Business Management. A table summarizing these intersections can be found in Appendix A.

We begin by reporting on our findings and analysis across all surveys, including those individuals who did not identify as being in either STEM or Business Management. We then turn to a subset of nine surveys, excluding two individuals who self-identified as not being educated and graduated in either STEM or Business Management.

Total graduate student surveys

For all fourteen fixed answer questions presented below, we used a five-point Likert scale, where 5 is strongly agree and 1 is strongly disagree. We acknowledge the small sample size of this study, which make the significance findings less reliable; however, the results are intriguing nevertheless.

For gender, we found that women were more likely to feel that they could contribute to the development of EDI-based knowledge as compared to the men in our sample. There were no significant differences to report on any other fixed answer type questions, when we grouped participants across gender.

With respect to sexuality, we found that heterosexuals were more likely than other sexual orientations (Queer and Bisexual) that their knowledge of policies with respect to EDI had improved, and that they could contribute to the development of EDI policies. The index of awareness of policies, which brings these two questions dealing with knowledge of policies and

contributing to development of EDI policies together, is also significant with heterosexuals being more aware compared to the other two self-identified sexual orientations. Similarly, we found that bisexuals were the least likely to be overwhelmed by the amount of work it would take to put an EDI research initiative in place, and that they would not stay quiet if they were faced with an *Othering* experience.

When we bring sexuality into two groups (Heterosexual and LGBTQ+), we observe similar results with respect to heterosexuals being more likely than individuals who identify as being LGBTQ+ that their knowledge of policies with respect to EDI had improved, and that they could contribute to the development of EDI policies. These two questions are part of the index of awareness of policies, which was also found to be statistically significant. In other words, heterosexuals had a greater awareness of policies and believed they could contribute to the development of EDI policies as compared to the LGBTQ+ group.

There were some significant differences to report when we look at racialized and ethnicized groups. Results were compared across 6 groups (categories for self-identification given in the questionnaire where Aboriginal/First Nations/Metis, Caucasian, Black, Asian, Open Answer, and Prefer not to Answer (N/A)) and an ANOVA was conducted for each question. Significant results were found for several questions. However, we have reason to believe that these differences was caused by one participant. The participant in question, Wanda[3], had responses that greatly differed from the rest of the participants sampled. For this reason, we chose instead to group the individuals into two groups, to which we refer to in this report as *white* and *visible minorities*[4]. Our results are such that the three students who self-identified as *visible minorities* are more likely to speak up and not stay quiet when faced with *Othering* experience as compared to the six students who self-identified as *white*. Remarkably, the three students who are more likely to speak up, were not STEM and/or Business Management students, whereas the six students who are more likely to stay quiet were either STEM or Business Management students. There might be an influence from the non-STEM and/or Business Management students discipline and this discipline's culture with respect to the awareness of resistance options. However, given our non-representative sample size, no generalizations can be made at this time.

With respect to education, persons with undergraduate degrees who are going into graduate studies are more likely to stay quiet as compared to those who are currently in Master's program or have their Master's degree.

These results are summarized in Table 2, Appendix B.

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[3] Pseudonym used to protect participant's identity.

[4] By using the term *visible minorities*, we are following the operational definition from Abella's (1984) recommendations to the federal Canadian government. However, we acknowledge the limitations and problems with respect to the use of such terms.

STEM and Business Management student surveys
We turn to the findings focused only on STEM and Business Management students. Again, for all fourteen fixed answer questions presented below, we used a five-point Likert scale, where 5 is strongly agree and 1 is strongly disagree. We acknowledge the small sample size of this subset of students, nine in all, which make the significance findings less reliable; however, the results are intriguing nevertheless.

Of the nine surveys that were completed by STEM or Business Management graduate students, there is one marginally significant result across gender. Women appear to have more positive feelings in believing they can contribute to the development of EDI-based knowledge as compared to men, keeping in mind that the sample size does not allow for a generalized interpretation.

With respect to sexuality, there are only significant results when the respondents were **not** placed into two groups (i.e. Heterosexual and LGBTQ+). Eight participants who self-identified as heterosexual felt that they would stay quiet if faced with an *Othering* experience, while one participant who self-identified as queer would not stay quiet. The small sample size we believe is a limitation with respect to this result.

There are no significant results for racialized individuals, grouped (*white* and *visible minorities*) or not grouped. Returning briefly again to all eleven surveys, we did report that there is a significant result for awareness of resistance options, where three students, who self-identified as *visible minorities* and are in non-STEM and/or Business Management fields, are more likely to speak up and not stay quiet when faced with *Othering* experience as compared to six students who self-identified as *white* and are in STEM and/or Business Management fields. There might be an influence from the academic discipline culture of these individuals with respect to the awareness of resistance options. However, given our non-representative sample, we cannot make any generalizations at this time. We believe we do not see any significant results in the subset of the surveys focused on STEM and Business Management students because the two individuals who self-identified as being outside of STEM and Business management self-identified as *visible minorities*. In other words, the total respondents in this subset of surveys that self-identified as racialized or ethnicized went down to three while respondents who self-identified as *white* remained at six.

There are some significant results with respect to education. Students with an undergraduate degree in either STEM or Business Management (who had just graduated and were going onto graduate studies) were more likely to stay quiet as compared to current or just graduated Masters students. Students in STEM fields felt they were in a better position to contribute to the development of EDI-centered research and to developing EDI-based knowledge as compared to Business Management students. The index of concept awareness also has a significant result, where STEM students are more aware of EDI concepts than business students. The small sample size again we believe is a limitation with respect to these results.

These results are summarized in Table 2, Appendix B.

Limitations of the Study

The limitations of this study include the small sample size. Unfortunately, two barriers beyond everyone's control impacted our ability to collect survey data from all participants during the summer institute week. First, ethics approval was granted the day after the summer institute finished, hampering our ability to collect data onsite. Second, the contract award and the funding mechanisms, governed by the University, meant that we could only start collecting data in September, 2019, a full 3 months after the institute took place. We have tried to highlight in the report where we felt the impact of the small sample size was most felt.

One Board member asked us to specifically address their question of enhanced impacts of STEM initiatives/inventions and "greater social equity and inclusivity". Our mandate for this research was to specifically look at EDI concerns at the intersection of STEM and Business Management, as a 'safe' area of discussion between two university faculties, one STEM and one Business Management. So while some of our participants who responded to our survey and who participated in our semi-structured interviews discussed inventions/initiatives such as artificial intelligence (AI) and concerns with bias not being addressed in AI, we did no go into detail about these concerns as they were outside of the mandate assigned.

Recommendations

Our recommendations are based on the Board's request to propose structural educational, pedagogical and social considerations at the EDI intersection of STEM and Business Management in higher education. We are suggesting an EDI framework, via our pedagogical and research approaches, and building on the results of this study. To this end, we recommend to the Board that:

1. An inclusive stance be adopted by higher education institutions, at the undergraduate and graduate level, such that men, women and trans+ individuals feel that they can contribute to the development of EDI-based knowledge and practices.

   This recommendation reflects that inequalities should not be left up to the people who are being marginalized to fight the battle themselves, a finding from this study, and reflects the literature. Universities need to take on the responsibility to address these challenges and to take concrete, measurable action. In spite of the academic literature recommending a study of cross-national patterns in the U.S., we recommend a national Canadian higher education statement on inclusivity.

2. Invite people who have power in STEM workplaces and within faculties of STEM to enact change with respect to EDI concerns.

   This recommendation reflects our findings in the empirical work conducted for this report. It also reflects the academic literature that diversity and inclusion in STEM and in STEM/Business Management is not only a government concern but

also an educational, social and economic concern. Similarly, per the literature, environmental and structural changes can benefit from involving individual change agents to enact EDI in STEM/Business Management.

3. Lobby and seek out funding opportunities from the Social Sciences and Humanities Research Council (SSHRC) to join NSERC's pilot grant program at small universities.
   This recommendation reflects the literature, both American and Canadian, that calls for higher education institutions to join the conversation on EDI concerns and to seek out funding to that effect.

4. EDI courses be part of core classes across Canadian universities, for undergraduate and graduate students, beyond concerns of faculty boundaries.
   This recommendation reflects our findings in the empirical work conducted for this report. Building awareness regarding equity, diversity, and inclusion through recommendation 1 and building such EDI courses into the curriculum moves higher education and industries away from arguments surrounding critical mass (e.g. having more women in classes and industry, thus placing this critical mass of women to be the one's responsible to 'fight the good fight').

   These core classes should preferably be mandatory courses during the semester but could also be run as a summer institute with Pass/Fail marking scheme, integrating students across various faculties together. Effective administrative support should also be offered to EDI lecturers to ensure a seamless course offering, across faculty boundaries.

5. Case-based examples of EDI concerns along with the following key concepts should be covered in higher education initiatives: intersectionality; knowledge (epistemology) such as bias in artificial intelligence (AI); Othering; decolonial/postcolonialism; women; Indigenous knowledges and concepts; and, diversity and human rights.
   This recommendation reflects the literature, the case-based approach to engaging students in learning and applying this knowledge, and our findings in the empirical work conducted for this report.

6. In line with recommendation 3, higher education institutions embrace the pedagogical need to educate students about policies with respect to EDI, and how students can contribute to the development of EDI policies. Higher education institutions need to recognize also that students may feel overwhelmed at times with these policies and policy creation exercises. Similarly, a different pedagogical framework with respect to policy understanding and policy creation needs to adopted for undergraduate vs graduate students.

This recommendation reflects our findings in the empirical work conducted for this report.

7. Recognize that various individuals with different backgrounds (e.g. race/ethnicity, academic discipline) speak up or stay quiet differently in the face of *Othering* experiences.

    This recommendation reflects our findings in the empirical work conducted for this report. By recognizing that individuals react differently to Othering experiences, higher education would be setting a precedence of understanding inclusion and diversity initiatives.

8. Recognize that various individuals may feel differently that they are in a better position after EDI training to contribute to the development of EDI-centered research and to the development of EDI-based knowledge.

    This recommendation reflects our findings in the empirical work conducted for this report. By recognizing that individuals react differently, even after a course on EDI principals, higher education would be setting a precedence of understanding inclusion and diversity initiatives.

Future Possible Work

As outlined in the contract, this report may be used by the CFBSD to further its knowledge and understanding of EDI concerns at the intersection of STEM/Business Management in higher education. We do plan to disseminate our findings in academic journals and conferences, as a way to further expand knowledge in EDI concerns at this particular intersection in higher education. We may also use the knowledge acquired from this exercise to influence further offerings of the summer institute or similar courses at the undergraduate and graduate level.

Future possible work includes participation in panel discussions on this topic and investigating opportunities for a larger sample size of respondents to our survey.

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Appendix A - Table 1: Survey Participants

Participant	Gender	Race	Sexuality	Education
Natasha	W	X	Hetero	STEM/BM/Other
Peter	M		Hetero	STEM/BM
Steve	M	X	Bi	Other
Stephen	M		Hetero	STEM
Jane	W	N/A	Hetero	STEM
Peggy	W		Hetero	STEM
Clint	M	X	Hetero	STEM
Carol	W		Hetero	STEM
Wanda	W	X	Bi	Other
Bruce	M		Hetero	STEM/BM
Mary Jane	N/A		Queer	STEM/Arts

Appendix B - Table 2: Fixed Answer Survey Results

Question	Complete Set of Surveys: Significant Results	Subset of Surveys: Significant Results
I feel that my awareness of resistance options has improved		
I feel that my knowledge of policies with respect to EDI has improved	Sexuality Ungrouped: $M_H = 4.4$, $M_Q = 4.0$, $M_{BI} = 3.0$ (p = 0.09) Grouped: $M_H = 4.4$, $M_{LGBTQ+} = 3.3$ (p = 0.058)	
I feel I can now contribute to the development of EDI policies	Sexuality Ungrouped: $M_H = 4.1$, $M_Q = 3.0$, $M_{BI} = 2.0$ (p = 0.006) Grouped: $M_H = 4.1$, $M_{LGBTQ+} = 2.3$ (p = 0.002)	
If I personally was harassed or discriminated against, I now feel I would speak up	Race/Ethnicity Grouped: $M_{VM} = 4.8$, $M_W = 3.5$, (p = 0.052)	
I feel I have gained an understanding of what social inequality and inequity means		
I feel, today, that I am in a better position to contribute to the development of EDI-centered research		Education $M_{STEM} = 4.7$, $M_{BM} = 3.0$, (p = 0.018)
I feel physically and/or mentally drained at the various options open to me with respect to my practice of resistance		
The amount of work it would take to put an EDI research initiative in place is overwhelming me today	Sexuality Ungrouped: $M_H = 3.1$, $M_Q = 1$, $M_{BI} = 4.5$ (p = 0.08)	
I feel I would stay quiet if I was faced with an Othering experience	Sexuality Ungrouped: $M_H = 3.9$, $M_Q = 2$, $M_{BI} = 5$ (p = 0.04) Race/Ethnicity Grouped: $M_{vm} = 4.6$, $M_w = 3.3$ (p = 0.036) Education: $M_{under} = 3.3$, $M_{Master} = 4.3$, (p = 0.117) marginally significant	Sexuality Ungrouped: $M_H = 3.9$, $M_Q = 2.0$ (p = 0.072) Education $M_{Under} = 2.7$, $M_{Master} = 4.2$, (p = 0.02)
I feel today that I can contribute to the development of EDI-based knowledge	Gender: $M_W = 4.8$, $M_M = 4.0$ (t=2.45, p = 0.037)	Gender: $M_W = 4.8$, $M_M = 4.0$, (p = 0.101) marginally significant

		Education M_{STEM} = 3.7, M_{BM} = 3.5 (p = 0.023)
I have a better understanding of inequalities and inequities in the business of STEM		
Index of Awareness Policies (AP): I feel that my knowledge of policies with respect to EDI has improved (10) I feel I can now contribute to the development of EDI policies (11)	Sexuality Ungrouped: M_H= 4.3, M_Q= 3.5, M_{BI}= 2.5, (p = 0.006) Grouped: M_H = 4.3, M_{LGBTQ+} = 2.8, (p = 0.004)	
Index of Concept Awareness (CA): I feel I have gained an understanding of what social inequality and inequity means (13) I have a better understanding of inequalities and inequities in the business of STEM (19)		Gender: M_W = 4.9, M_M = 4.5, (p = 0.101) marginally significant Education M_{STEM} = 4.9, M_{BM}=4.3, (p = 0.023)
Index awareness of resistance options (RO): I feel that my awareness of resistance options has improved (9) If I personally was harassed or discriminated against, I now feel I would speak up (12) I feel physically and/or mentally drained at the various options open to me with respect to my practice of resistance (15) I feel I would stay quiet if I was faced with an Othering experience (17)	Race/Ethnicity grouped: M_{vm}= 4.2 , M_w = 3.5 (p = 0.029)	