50 Positive and Impactful Texts

Message from the minister **Isabelle Charest**
Foreword by **Janice Bailey** and **Fanny Eugène**
Epilogue by **Maryse Lassonde**

Manifesto about Women in STEM

Science, Technology, Engineering and Mathematics

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Catherine Pallascio | Joëlle Pelletier-Nolet | Jennifer Petrela | Pauline Provencher
Elyse Robin-Boulanger | Anne Roy | Claudie Solar | Amina Yagoubi

JFD Éditions

Produced by the AFFESTIM team

Association de la francophonie à propos des femmes en sciences, technologies, ingénierie et mathématiques

50 Positive and Impactful Texts

Manifesto about Women in STEM

In 2022, how are women in STEM (science, technology, engineering and mathematics) faring?

The Manifesto about Women in STEM is a collection of 50 texts that speak to the population at large. It brings together the thoughts of several authors, including individuals (both women and men) and groups from the school, university and private sector realms, who work with women in STEM in French-speaking Canada. This Manifesto is intended to be positive and impactful, even if work still remains to be done to achieve equity and equality. Several important issues are still current, such as work-family balance and motherhood without penalty. Issues such as intersectionality, EDI (equity, diversity and inclusion) and the impact of the COVID-19 pandemic on women in STEM are also explored. There are texts that address the intersection of STEM and each of health, the arts, education and philosophy. Others deal with women who experience multiple forms of discrimination, for example Indigenous women and non-heterosexual women in STEM. Pioneers relate their obstacle-ridden but fulfilling journeys. Seven recommendations are proposed for a society looking to achieve equity, diversity and inclusion of women in STEM in an intersectional perspective.

Invitation to sign the Manifesto:
http://uqtr.ca/manifeste.femmes.stim

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Québec Mining Association

AFFESTIM

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Web: editionsjfd.com

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Message from the minister

It is remarkable that thousands of women choose, at one point or another in their lives, to dive into predominantly male fields such as science, technology, engineering and mathematics (STEM). Yet, despite their ever-growing numbers, these devoted and passionate women continue to often feel quite alone in this universe. Still a minority in STEM fields, they face many obstacles and struggle to access and occupy their rightful place.

The presence of a greater number of women in male-dominated employment and training sectors is a key issue in achieving equality between women and men and requires community commitment. The different and complementary skills of women and men are of immense benefit to key fields of activity which are at the heart of our community's prosperity and innovation. Ladies, your different view of the world allows you to enrich these sectors and propel them forward!

You hold in your hands proof of the richness of women's involvement in science, technology, engineering and mathematics. In this collection of texts, women of all ages and backgrounds, through their personal and professional experiences as well as their research, express their point of view and their demands, and depict a portrait of realities that are greatly worth reading and sharing.

Thank you to all of you, exceptional women one and all, for sharing your explanations and your enlightened points of view with us! You are models who will inspire young girls and women who would like to follow your example. We greatly need it.

Isabelle Charest

Minister of Education and
Minister of the Status of Women

Foreword

We are honoured to contribute this foreword to the *Manifesto about Women in STEM: 50 Positive and Impactful Texts*, whose positive and pedagogical approach matches our own optimistic view of the status of women in science, technology, engineering and mathematics (STEM).

Despite slow progress in representation, women have made their mark and demonstrated their important contribution to the field. No one today would question whether women belong in STEM. The hard work of numerous women, many of whom are among the authors of this book, has helped to facilitate, strengthen, and promote the place of women in STEM.

In addition, as noted in a few of the texts in the *Manifesto*, initiatives put in place in recent years by higher education institutions, granting agencies and other scientific organizations are beginning to pay off.

One such program is Engineers Canada's "30 by 30" initiative, whose goal of achieving 30 percent female representation among new members of professional engineering associations by 2030 has been taken up – and in some cases already achieved – by engineering schools in Quebec.

Other more recent initiatives, such as the Marcelle-Gauvreau engineering research chairs program at the *École de technologie supérieure*, also promise interesting spin-offs. We are convinced that Quebec has the potential to position itself as a leader in this field. Already in 2017, the government's Strategy for Equality between Women and Men and the Quebec Research and Innovation Strategy included objectives to increase the presence of women in scientific careers. At the *Fonds de recherche du Québec – Nature et technologies (FRQNT)*, the attraction, retention and advancement of women in STEM have also long been strategic priorities.

In addition to measures aimed at the work-study-family structure, the FRQNT has recently introduced, in all its grant programs, evaluation criteria on the efforts made by individuals and teams to

promote equity, diversity and inclusion (EDI) in their environments and in the research itself. These actions of the FRQNT are part of a broader effort by the three *Fonds de recherche du Québec* to strengthen EDI in all research sectors. In order for efforts to promote the place of women in STEM to benefit all women, they must be part of an intersectional approach, taking into account the diversity of realities experienced by different groups of women. The section of the *Manifesto* entitled "Intersectional matters for women in STEM" offers a reflection on this subject that we believe is essential. Obviously, there is still much work to be done to achieve true equity and inclusion of women in STEM. The growing representation of women studying in STEM fields is encouraging, and we need to ensure that these students are able to establish themselves in careers that are commensurate with their talents. Among other things, major efforts are still needed to ensure that a greater number and diversity of women have access to decision-making positions within organizations. Everyone working in STEM, especially those in leadership positions, should read this *Manifesto*. It is an essential tool for understanding the current situation, discovering inspiring initiatives, and sparking reflection that will lead to a stronger place for women in STEM.

Janice Bailey

Scientific director of the *Fonds de recherche du Québec – Nature et technologies*

Fanny Eugène

Strategic Advisor – Equity, Diversity and Inclusion of the *Fonds de recherche du Québec*

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We would like to begin by sincerely thanking all the authors and the organizations in which they are involved who responded enthusiastically to our call for papers. The richness of their respective expertise has guided and supported us throughout the preparation of the 50 texts of this *Manifesto*.

We hope that everyone will find their own reflections and suggestions embedded in these works and will come out as enriched as we did from this singular experience of sharing content as authors.

We could not have published such a book without the financial support of our partners and accomplices: the *Secrétariat à la condition féminine du Québec*, the *Fonds de recherche du Québec – Nature et technologies (FRQNT)*, the *Université du Québec à Trois-Rivières (UQTR)*, the Département des sciences de l'éducation de l'UQTR, the *Association minière du Québec* and the *AFFESTIM (Association de la Francophonie à propos des Femmes en Sciences, Technologie et Mathématiques)*.

We warmly thank Mrs. Isabelle Charest, Minister of Education and Minister of the Status of Women, for her introductory message to our *Manifesto*. In addition, we cordially thank Janice Bailey and Fanny Eugène, respectively Scientific Director of the Fonds de recherche du Québec – Nature et technologies and Strategic Advisor – Equity, Diversity and Inclusion of the *Fonds de recherche du Québec*.

We thank Mrs. Maryse Lassonde, President of the *Conseil supérieur de l'éducation du Québec*. We also thank the online magazine *La Conversation* for allowing us to publish an adapted version of Louise Champoux-Paillé and Anne-Marie Croteau's text entitled "The pandemic might have an impact on the place of women at our universities". The University of Quebec Press agreed to allow us to reprint texts from the book *Dear mathematics: Encouraging the expression of emotions in mathematics*, by Louise Lafortune and Bernard Massé, in collaboration with Serge Lafortune. We are grateful to them.

Noëlle Sorin revised all the texts. We thank her warmly for this important contribution to the clarity and coherence of the *Manifesto*. Éditions JFD have also been of precious and efficient help. We thank the translators for their excellent work: Rebeca Torres Serrano, Yilennis Rodríguez Ramírez, Claudia Lianet Córdova Figueira, Katerine Santos Rodríguez and Elianis Páez Concepción. We also thank Vilma Páez Pérez and Salvador Escalante Batista for their fine work in revising the book. We are grateful to Hélène Roulston, who provided a high-quality linguistic revision of the book. We also acknowledge the unfailing support of the members of AFFESTIM, who are both our muses and our pillars. In particular, we would like to acknowledge the generous and valuable participation of the women pioneers who have agreed to contribute their expertise and insightful experience to these texts.

Louise Lafortune
Audrey Groleau
Claire Deschênes

Introduction: *Manifesto* Origins

On January 16, 2020, the *Association de la francophonie à propos des femmes en sciences, technologies, ingénierie et mathématiques (AFFESTIM)* held a policy workshop where the idea of creating a positive and impactful manifesto on women in STEM was adopted. It was clear that for over 30 years, questions like "Does science have a gender?" had remained open and it was time to affirm that women and men in STEM are equal. We saw this *Manifesto* idea as a unique opportunity to take stock, openly and positively, of the situation of women in STEM in the Canadian French-speaking world, which we hoped would allow us to stop asking ourselves these questions that have no place in today's world.

Thus, in the spring of 2020, Louise Lafortune, Audrey Groleau and Claire Deschênes invited the members of AFFESTIM and, more broadly, groups and individuals working on the subject of women in STEM, to write short texts to nourish this *Manifesto*, while taking into account their expertise and reflections. The 50 works that make up this *Manifesto* were born from these writings that were generously sent to us, which were sometimes merged, enriched or harmonized so that each final version focused on a specific theme. This means that the texts of the *Manifesto* are no longer the work of one or more individuals but belong to all the authors whose names appear on the cover. All the pieces in this collective work are proudly signed by all these expert and generous people, who have unanimously accepted this unique way of working. For us, it was essential that this be a truly collective work. It should be noted that each signatory to this *Manifesto* considers that they agree with at least 80 percent of its content.

We hope you enjoy reading the *Manifesto*. Three outstanding women scientists from Quebec government agencies, Maryse Lassonde, President of the *Conseil supérieur de l'éducation du Québec*, Janice Bailey, Scientific Director of the *Fonds de recherche du Québec – Nature et technologies*, and Fanny Eugène, Strategic Advisor – Equity,

Diversity and Inclusion of the *Fonds de recherche du Québec*, have signed the foreword and epilogue of the book to put it in context. Three poems were also added to the book. Although equality and equity have not yet been achieved for women in STEM, we already know collectively that, for one, women and girls have the same potential as men and boys in STEM and that, secondly, the situation has evolved positively over the past 30 years thanks to the combined effort of many women and men in the educational, governmental and scientific communities. One of the objectives of this *Manifesto* is to reveal the current situation of women in STEM. It shows that this quest is unfinished, but that some emerging issues are hopeful. The second objective is to publicize and recognize the role played by AFFESTIM and its collaborators for the advancement of women in STEM and the fight that we could continue to lead collectively in the future.

What do we discover in these 50 texts? We find information on the current situation of women in STEM as a group and, for certain professions, the laying bare of preconceived ideas, stereotypical affirmations and other prejudices that have been circulating for too long, the challenges that remain and the obstacles that persist, such as the difficult work-family balance. Several texts offer original and proven ways to improve the situation of women studying or working in STEM. We also wanted to seek out pioneers in the movement who would explain, in relation to their own professional careers, the evolution of the situation of women in STEM and their perceptions of past and future matters. In addition, several texts deal with emerging issues in STEM, such as those of women who belong to all kinds of minorities.

Speaking of emerging issues, since this orientation workshop in January 2020, the planet has been ravaged by a pandemic unprecedented for our time, that of COVID-19. Feminist STEM issues in relation to health and medical matters related to the pandemic have become preeminent. For this reason, AFFESTIM conducted a reflection on the very definition of the broad field of STEM, which led it to include health professions and jobs. The results of this reflection are the subject of the first text of the *Manifesto*.

We conclude with seven recommendations, one for each of the seven sections, followed by suggestions for pedagogical use of the *Manifesto about Women in STEM: 50 Positive and Impactful Texts*. The website www.uqtr.ca/manifeste.femmes.stim allows anyone who supports this initiative to sign this *Manifesto*. We hope that many will join in.

Happy reading!

The *Association de la francophonie à propos des femmes en sciences, technologies, ingénierie et mathématiques (AFFESTIM)* was created in response to a resolution of the participants of the Quebec Round Table at the 12th International Conference of Women Engineers and Scientists, held in Ottawa in July 2002. Participants from several Canadian francophone organizations expressed their desire to join forces to strengthen their activities in Quebec, the rest of Canada and, more broadly, in the francophone space. AFFESTIM was created on July 24, 2003, under the *Canada Corporations Act* (file 417874-2), as a non-profit organization. Its co-founders are Louise Lafortune, of the MOIFEM association (1986-2003), Claire Deschênes, of the NSERC/Alcan Chair for Women in Science and Engineering (1997-2005), and Marie Bernard, of the Marianne-Mareschal Chair (1998-2016). The launch of AFFESTIM took place at the Université du Québec à Trois-Rivières, during a conference on the topic "Science, Technology, Engineering and Mathematics: Reflections and actions for the next generation". At that time, the Association had members from New Brunswick, Nova Scotia, Ontario and Quebec, which gave it a national character. AFFESTIM's mission is to bring together individuals and organizations from the French-speaking world interested in promoting the participation, retention and advancement of women in fields related to STEM (science, technology, engineering and mathematics).

1

WHAT IS STEM IN 2022?

At the time of the creation of AFFESTIM, in 2003, a discussion was held to specify the meaning of the acronym AFFESTIM. Two possibilities were then examined:

AFFESTIM: Association de la francophonie ***pour***[1] les femmes en sciences, technologies, ingénierie et mathématiques

AFFESTIM: Association de la francophonie ***à propos***[2] des femmes en sciences, technologies, ingénierie et mathématiques

We chose the second name. Already, at that time, we intended for AFFESTIM to welcome people who have an interest in the situation of women in STEM or who do research in this field, whether they themselves work in STEM or in another sector. For example, AFFESTIM membership has always included researchers in the humanities or education who are interested in women's issues in STEM.

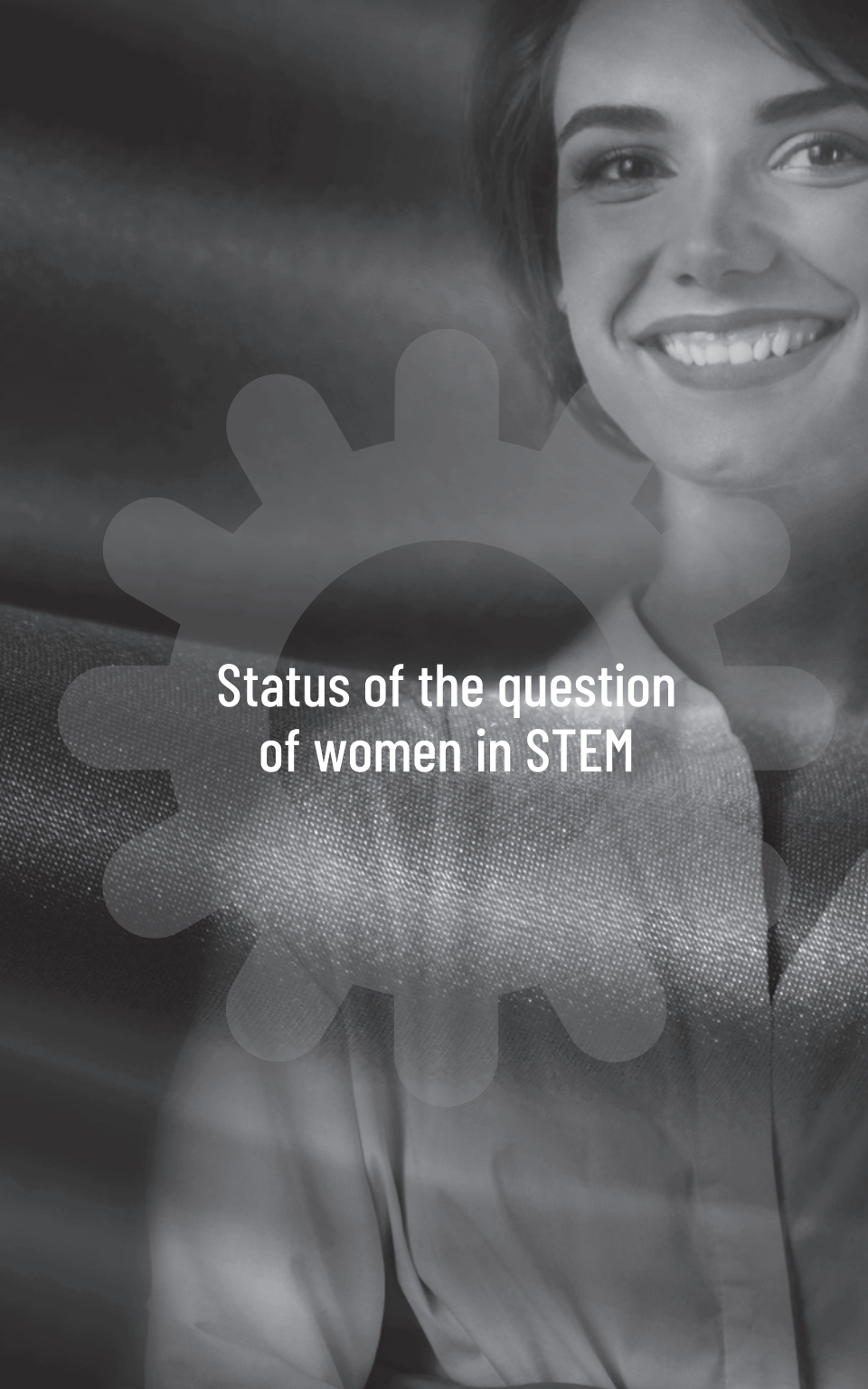
Today, in light of the above, it is pertinent to revisit the STEM challenge to be more inclusive and explicitly include women scientists working in the health field, which was not the case before. This concern becomes even more important in light of the current

1. for
2. about

COVID-19 pandemic situation and the critical role of health sciences in addressing it. Therefore, we propose a new definition of STEM as follows:

- **S** for biological, chemical, physical, health and other sciences;
- **T** for information, communication, artificial intelligence, computer, health, laboratory and other technologies;
- **E** for all branches of engineering;
- **M** for mathematics.

For us, the important thing is to involve all the people who are interested in the situation of women in STEM or who work in this field in AFFESTIM, regardless of their gender, sexual orientation, ethnocultural origin, socioeconomic and sociocultural situation, religious conception, disability situation, and so on. To this end, we adopt an intersectional perspective and a concern for equity, diversity and inclusion (EDI).



Status of the question of women in STEM

2

DEAR MATH: CHILDREN'S LETTERS TO MATHEMATICS[1]

Hello math! X + Y =

I wanted to thank you for teaching me so much. Without you, I would never have known how to add or subtract. When I was in elementary school, I liked you because I often had fun adding numbers. As I got older, I thought I lost interest in you, but I realized I was wrong. I could never forget you. You are my life. Without you, I would not be in a high school math class. You taught me the art of math. A little bit of algebra, a little bit of geometry, a little bit of logic, well, a little bit of everything. For me, you are an asset. I love you and I can't wait to learn more from you. You are a little difficult to understand, I find that there are a lot of formulas and that math requires concentration. Despite all that, you are quite pleasant.

From a student who loves you

Dear math,

For me, you represent a whole universe. I must admit that you have never been my specialty. I am a very emotional person, and I love to express myself through words, both spoken and written – and through gestures. I find that you don't mix well with my personality because I can't express my feelings in this area. I like to describe the beings and things around me, and I like to communicate with them. With you, I can't do that. I also find you too abstract. I know that it is good to learn and develop new knowledge. However, I doubt I will use you in my career unless I change my mind and go into a field that requires a math background. I am mostly interested in subjects that are part of everyday life, such as French, English, history and music. These subjects help me shape my personality, my culture, my philosophy of life. Until now, what I learned about you up to the sixth grade has been enough for me. I do calculations every day, but I don't use the math I learned in high school. For this reason, math sometimes seems unnecessary and not relevant to me. Nevertheless, I'm interested in you for one reason: you make me think and reflect. It is a real challenge that I love to face every day.

From a boy who thinks math is useless but loves its challenges

3

A LONG JOURNEY: THE PRESENCE OF WOMEN IN STEM IN COLLEGE AND UNIVERSITY

Since the 1970s, the position of women in Quebec's colleges and universities has improved greatly. They are currently the majority in most fields. But what about in STEM fields? Are they more invested in these fields today? Data collected from Quebec's Ministry of Education and Higher Education shows that, although more and more women are enrolling in college and university programs in pure and applied sciences and in engineering, these two major fields still have the lowest proportion of women compared with men. In 2018-2019, women overwhelmingly enrolled in bachelor's degree programs in the humanities (74%), education sciences (74%), and health sciences (78%), while accounting for only 43 percent of enrolment in pure and applied sciences and 22% in engineering (Belletête, Pelletier-Nolet, Brodeur, & Langelier, 2020).

Even though there is still a long way to go, the data is encouraging in some STEM disciplines in which women had very low attendance about 15 years ago. For example, from 2007 to 2019, engineering was the academic field with the largest growth in female enrolment at the bachelor's (16% to 22%), master's (23% to 28%) and doctoral (20% to 27%) levels. In the sciences, at the bachelor level, women are making good progress in disciplines where they are traditionally in the minority, namely computer science (from 10% to 19%), physics (from 18% to 24%) and mathematics (from 38% to 41%).

Some disciplines still attracted few women in 2018-2019 at the university level (electrical engineering at 12%, mechanical engineering at 15%) and at the college level (electronics and computer

technology at 6%, aeronautical technology at 11%, mechanical and industrial engineering technology at 12%). However, other university STEM disciplines had a significantly higher presence of women in 2018-2019, such as biological and biomedical engineering (53%), food engineering (54%), biology (65%), microbiology (68%) and food science and technology (72%).

The figures show an increase in female enrolment in some key areas. The situation is evolving slowly but in the right direction, which could be a sign that Quebec's initiatives to raise awareness of STEM careers among girls and to counteract the stereotypes associated with them are gradually bearing fruit.

Nevertheless, it is important to pursue efforts and strategies to encourage the participation of women in these fields in order to move towards parity. There is ample research evidence showing that gender diversity stimulates research, innovation and creativity. It is also important to continue to raise awareness of these fields of study and associated careers among young girls so that they can picture themselves in them and understand that they can contribute to and improve the world of tomorrow. While it is always interesting to measure the progress of women through numbers, it is important to remember that achieving statistical parity does not guarantee equality in terms of employment. Achieving 30 percent or 50 percent women in a field does not mean that everything is settled. There is also a need to continue to ensure, among other things, that women are well cared for in STEM workplaces; that organizations make certain that women are well integrated; and that women are encouraged to move into leadership roles. This will ensure that they have a successful career in these very rewarding fields.

4

WOMEN IN ENGINEERING FOR A THRIVING SOCIETY

Feminist engineering research helps to promote public understanding of the discipline, ensure its economic and societal contributions are recognized, and encourage equal opportunity. This includes identifying structural and systemic barriers to gender equality in the field of engineering and providing a critical analysis for cultural change.

The bilingual (French-English) pan-Canadian study *Le génie au service des femmes: Rethinking the Faces and Spaces of Engineering* (Mujawamariya, Mavriplis, Fournier, & Adatia, 2018) explores how women and men engineers are contributing to the advancement of engineering research and technological innovation for the benefit of women, as well as presenting the challenges they face in engaging with women's issues. The researchers responsible for this study asked themselves the following questions:

- How do people studying and working in engineering view engineering?
- What importance do they place on the role of women engineers as agents of change in advancing science and technology research on issues concerning women?
- What barriers impede the investment of these women in typically female issues?

This study also offers concrete suggestions that may encourage and prompt women engineers to examine issues of typical female interest and develop innovative responses. The study was conducted through interviews followed by a questionnaire. The 1 543 female and male

participants were from a variety of backgrounds and were studying at all three university levels (Bachelor, MA and PhD), teaching engineering or working in business and engineering.

One of the highlights of this study is that those who responded to the questionnaire most often agreed with the following statements (the percentages represent those who strongly agreed or agreed with the statement):

- Engineering is the application of science, mathematics and technology to design and solve problems (97%);
- Engineering requires the cooperation of people (93%);
- Engineering is necessary for the betterment of society (92%);
- Engineering is about developing effective solutions to a particular problem (93%);
- Engineering is considered an innovative way of transforming people's lives (79%).

A major finding resulting from this study is the recognition of women's unique contributions to engineering (Mujawamariya, Mavriplis, Fournier, & Adatia, 2019) because of their different ways of addressing problems facing their communities and society at large. In this regard, the words of a young professional with a master's degree in mechanical and biomedical engineering are very meaningful: *It's nice to put your finger on exactly that, but I think women have a bit of a maternal side, they are more sensitive to emotions, to the needs of the world. I think that men and women bring values that are necessary in order to have projects that are equitable on a societal level. It's not to say that women are better than men, it's just that they bring attributes that aren't necessarily popular with men*.

Unfortunately, when it comes to typical women's issues, enthusiasm is not easy to find, hence the need for more recruitment and the need for greater recruitment and retention of women in engineering (Mujawamariya & Mavriplis, 2017). To this end, a change in the engineering culture is needed, when we see that nearly three-quarters (73%) of respondents to the survey admit that the engineering culture is male-dominated. This culture is driven by profits (in

industry) and research spending (in academia) according to 66 percent of participants. It is described as intense by 47 percent of respondents. Finally, 13 percent (a majority of whom were women) said that it was a culture that was downright hostile to the realities of women's lives. The table below highlights the differences between women's and men's perceptions of engineering culture. This persistent culture is undoubtedly one of the causes of the under-representation of women in engineering.

Table 1: Women's and men's perceptions of engineering culture (%)

	Women	Men	All participants*
Male dominated/biased	81	57	73
Goal-oriented	51	70	58
Favourable/positive	26	31	28
Intense	49	43	47
Hostile	16	6	13
Learning-oriented	29	33	30
Determined by profits (in industry) and research spending (in academia)	65	68	66

* Note that the total of all participants includes agender and non-binary individuals.

As mentioned by participants, in order to overcome this problem, it is important to work with a variety of parents, teachers, guidance counsellors, company managers, faculty members, active professionals and the community at large (Mujawamariya, Mavriplis, & Fournier, 2019).

To move beyond these findings, greater awareness of the contribution of women engineers to engineering, as well as a better appreciation of this contribution, are crucial. Further research on the representations of engineering by future engineers and on the role of women engineers in issues of concern to women is also essential. Increasing the visibility of positive female role models in engineering would be valuable, as would the development of policies to encourage the presence and active participation of women in the multiple sectors of engineering.

5

PROMOTING THE ORIENTATION OF WOMEN IN STEM AND THEIR RETENTION IN THE FIELD[2]

Women are already in short supply in some STEM fields, but many also leave these fields during their studies or in early or mid-career, before they have had a chance to significantly develop their skills in these disciplines in a meaningful way. While the situation has improved over the past 30 years, there is still work to be done to ensure that the conditions of access to jobs are equitable between women and men.

In the STEM fields (and surely in other fields), the "glass ceiling" is a reality. This term means that women and other minority groups are struggling to reach high-level positions. It is as if there is a ceiling that prevents people belonging to these groups from moving up the hierarchy. The existence of this ceiling, which is often difficult to reach and then to break through, has unfortunate consequences on women's career choices, and sometimes dramatically, for women who are marginalized because they are minorities, live with a disability or have a sexual orientation that is not accepted in the community. Not only are there fewer women than men in STEM, but they also stay in STEM for shorter periods of time, in part because of the difficulties in advancing their careers (Hewlett, Buck Luce, & Servon, 2008).

The low presence of women in STEM is already an issue at the studying stage. For instance, female students may leave STEM to try other fields of study or to explore the job market. There is a variety of reasons why they may want to redirect their focus and initiate such a change in their lives. It may be due to high levels of

stress because of exams or assignments or to pressure to perform or to the difficulty of balancing school, work and personal life (American College Health Association, 2009; Grant, 2002). Female students may want to change their environment because of conflicts with fellow students, professors or their research supervisor (Litalien, 2014). Some of the reasons for these changes in orientation are also related to the research environment requiring higher levels of study. Other students want to change direction because of a decline in motivation in relation to their field of study. They may feel that they are not competent or successful enough. Knowing the nature of the tasks to be accomplished leads others to realize that these tasks are different from what they thought and do not meet their expectations, needs or aspirations. These realizations change the perception of the occupation or career choice and make the chosen STEM field less attractive than it was at the time of enrolling in a program of study.

For women already in the workforce, the reasons for a career change are also diverse. They may be related to the atmosphere, the working conditions or experiencing discrimination. However, wanting to change fields is also a way to meet other career needs, such as the desire to work more with people, to do less technical work and more administrative work, or to work outdoors.

Girls and women who are questioning their educational or career choices should ask themselves some questions before giving up or quitting. These questions can help them determine whether their need for change is due to internal causes, such as a lack of fit between the demands of the job and their personality, or the fact that their desires, tastes and aspirations are not being met. The change they are considering may also depend on external causes, such as performance pressure, perceived discrimination, gender inequity in the distribution of tasks, harassment by certain colleagues or sexist remarks. This is an opportunity to reflect on the reasons that led to this professional or study choice and to question the reasons for wanting to leave the STEM world. Making the right career change decision requires taking the time to adjust to the field, to ask management to address problems, and to understand all the field's facets and career possibilities.

To make informed choices, it is often relevant to seek advice from key people around you, women role models who can serve as mentors or resource persons who help you think things through. It is also sometimes useful to solicit the perspective of people from outside of STEM in order to broaden your horizons. Resources exist[3]: it is a matter of finding out about them and consulting them. Competent and self-sufficient people know how to assess their needs for consultation and assistance and, above all, undertake to solicit these resources.

6

WOMEN IN DECISION-MAKING POSITIONS

Women within and outside of STEM are at the mercy of social roles associated with patriarchy. Although women make up more than half of the world's population, they occupy only 20 percent of decision-making or leadership positions. Their situation in STEM fields reflects this. As in other areas, it is influenced by the social roles linked to the patriarchal past of our societies. However, at the 1995 Beijing World Conference on Women, several countries agreed to achieve a 30 percent representation of women in senior government and political positions. Nevertheless, this is nowhere near being achieved.

According to Karpowitz and Mendelberg (2014), the 30 percent target is not the only measure to attract women to apply for high-level positions in these institutions. The institutions themselves would also be tasked with implementing equitable and egalitarian policies and practices to improve not only their own situation, but also that of women. Thus, decision-making bodies that value women's ideas and take into account their experiences often have a more just and equitable impact on those affected by their decisions. In fact, women's life experiences are different from those of men, and their values often show the ethics of care that leads them to consider the well-being of people in their decisions.

ORIGIN OF THIS SITUATION IN CANADA

Patriarchy, which is rooted in our culture and collective history, still influences the social roles attributed to women and men, to the point that society perceives the practices and behaviours derived

from it as being the natural order of things. Indeed, the division of social roles gives men the power to make decisions in the public sphere, while women's role is located more in the private sphere.

Canadian women obtained the right to vote in 1918 (1940 in Quebec). A few years later, on October 18, 1929, five Lords of the Privy Council of the United Kingdom made a decision that would change the course of our history. Following a petition to the Canadian government by five Canadian women, the British North America Act in the Canadian Constitution (section 24) was amended so that the definition of the word person would include women as well as men. This landmark episode is considered one of the key events in the history of Canadian women's struggle for full citizenship and a triumph of democracy, as it finally stipulated the equality of women and men as nation-builders (Gaudet & Lapointe, 2004).

In 1973, the United Nations General Assembly mandated the Commission on the Status of Women to prepare a draft convention on the rights of women. One-third of the objectives focused on the education and training of girls and women, which opened the door to post-secondary education and participation in better-paying jobs. It made it possible for more of them to engage in fields of study and employment that were once reserved for men.

CHALLENGES FOR WOMEN IN TRADITIONALLY MALE FIELDS

In the early 1980s, feminists were vocal in demanding the right to representation of women in all spheres of human life and their rightful place in society. Studies conducted by the Quebec government in the late 1980s and early 1990s on the challenges faced by women in STEM fields of study and employment highlighted obstacles related to the presence of sexist behaviours and attitudes (including gender-based and sexual harassment), the gendered division of labour, and the lack of appreciation of women's work in government institutions (Government of Quebec, 1989, 1993, in Gaudet & Lapointe, 2004). Cultural challenges prevented many

women who studied and worked in these institutions built by and for men from reaching their full potential while depriving these institutions of valuable experiences for their development.

WOMEN IN SOCIAL INSTITUTIONS AT PRESENT

There is still a negative prejudice towards the female model of speech, which is less valued than that of men, especially when women are in the minority at the discussion table (Belenky, Clinchy, Goldberger, & Tarule, 1986; Lakoff, 1975; Spender, 1980; Tannen, 1990, in Ouellette, 1999). According to these authors, women are faced with a society that devalues their voice. Representing only a minority in politics and decision-making, they tend to express themselves much less than men, who perceive them as having little influence within the team (Baider, 2004). Many of them, who feel less heard, recognize that their power within the group is rather limited. Furthermore, men who speak up receive more positive reinforcement than women in these places of power, which may decrease their self-confidence. This negative prejudice is related to the gender of the person (Ouellette, 1999), as social representations construct a set of gender-differentiated expectations and appreciations, which explains the unequal value attributed to female and male attitudes in prestigious social spaces (Council on the Status of Women, 2015). Baider (2004) argues, for example, that the word "woman," associated with adjectives such as "weak," "small," "easy" and "light," has a pejorative connotation, while the adjectives "tall," "clever" and "honest" are used to describe the word "man".

Numerous studies show that more women are now involved in STEM studies and jobs, although they still face systemic barriers. This field still has a long way to go to break down barriers that prevent these women from playing a more influential role professionally, politically and socially. In order for girls and women to continue to participate in decision-making in traditionally male fields, especially in STEM, it would be appropriate to create conditions for their participation in deliberative discussions and, above all, to develop measures that can put an end to inequitable policies and practices.

7

FOR MORE EQUITY IN SCIENCE AND ENGINEERING MAJORS

The glaring shortage of women professors in science and engineering faculties has prompted universities to adopt hiring policies in favour of women and their career advancement. The realization of a systemic problem – few women available and CVs that do not necessarily meet hiring requirements, particularly in terms of the number of publications – has resulted in a real desire to improve the selection process for future female professors and the creation of specific programs to encourage their hiring, such as designated chairs and scholarships to encourage the recruitment of women. Nevertheless, these hiring initiatives have sometimes been perceived as less prestigious, leading to the perception that women in these positions are less worthy than those hired the traditional way. This discomfort was highlighted when the Natural Sciences and Engineering Research Council of Canada's (NSERC's) University Faculty Awards Program was discontinued.

In a multi-disciplinary research study on women in traditionally male occupations, one research team focused on women in the field of engineering. This topic led the team to extend the study to include women professors in science and engineering (Deschênes et al., 2019b). Female professors from several Quebec universities were interviewed using a range of questions about their profession.

The interviews with these professors brought several facts to light. An academic career is exciting and rewarding yet very demanding. This is even truer in the first few years, before tenure is granted. Competition for research grants and industry partnerships is constant. Excellence is often quantified, in the sense that professors are

evaluated by the number of scientific articles they publish and the amount of research funding they receive. Active participation in international conferences to develop a research network and practice and to make their work known is essential. Nevertheless, the need for mobility remains a major concern for female professors, who perceive these conferences as an additional task that is often difficult to reconcile with family constraints.

In the applied sciences, the conflicting demands of granting agencies and industry weigh heavily on the shoulders of female professors. While it is important to have numerous scientific publications in order to obtain research grants, industry demands a high level of involvement in applied research activities, which are not always publishable in scientific journals. As a result, female professors feel that they are short of time and have to work twice as hard to meet all these demands, while carrying out teaching duties, postgraduate students' supervision and assuming administrative and community service responsibilities.

In the case of research grants, the peer review committees that evaluate the applications are encouraged by the granting agencies to take into account the specificities of women and visible minorities, including maternity leave and personal obligations. Is this enough? Because of the competitive nature of these applications, performance criteria that have not changed much are still too often applied. The women professors consulted deplore the quantified and standardized performance requirements that imply many sacrifices. Family obligations seem to them incompatible with an academic career, which requires total dedication. They live in perpetual tension, torn between their professional and personal lives. This is why many of them have chosen to focus on certain types of work, such as teaching and administration, to the detriment of research.

In order to change the current situation, faculties should acquire indicators and set targets that take into account the realities of women in academia, adjust them regularly and verify that they are being met[4]. They could consider a better distribution of work within their ranks so that the expertise of each academic staff member is maximized. Indeed, a more equitable distribution of tasks would allow female professors to develop their research CVs to the same

degree as their male colleagues. The requirements for the number of publications and grants obtained would be reduced to a more reasonable and equitable level, regardless of the gender of the candidates.

In summary, career advancement and granting are too often dependent on a system that obsesses over quantifying the impact of research at the expense of the quality of the work and the contributions of female professors to the faculties. This system does little to promote healthy working conditions or a proper balance, both personal and professional. This overall problem has led some universities and funding agencies to introduce measures to improve the work-life balance of female professors, including taking into account the impact of maternity leave on career advancement and on the evaluation of grant applications. Nevertheless, these measures remain insufficient in terms of how excellence is still understood in the academic world today.

8

WOMEN MATHEMATICIANS IN HISTORY: GETTING TO KNOW WOMEN SCIENTISTS

The lives of Mary Fairfax-Somerville (1780-1872), Sofya Kovalevskaya (1850-1890) and Emmy Noether (1882-1935), and specifically their relationship with mathematics, help to understand the status of women in STEM today (Lafortune, 1988). These three women are respectively from Scotland, Russia and Germany. What they had in common was that they lived in places where the development of science was in full swing. Although they came from relatively well-to-do families, they were personally confronted with difficult financial conditions. The fees Mary received from her publisher were sent to her husband. Sofya received little from her family and received little or no compensation for her work. Emmy seems to have had more favourable conditions, but it is said that her needs were few and that she lived on mathematics.

Demonstrating a rebellious spirit, these three women went against the social norms of the time, which destined them to the life of wife and mother. Mary emphasized the benefits of her freedom during her widowhood, Sofya entered into a platonic marriage to free herself from her parents' guardianship, and Emmy remained single and devoted her life to mathematics research. Mary's parents considered it hazardous to a woman's health to study and do mathematics; she used candles to read and study at night, and kept her work secret. Sofya also hid to study, afraid she would be discovered. Faced with her determination and proof of her abilities in the field, her family had to give in to her desire to study mathematics. Emmy was born at a time when women were beginning to be accepted in intellectual circles, but there was no shortage of obstacles. It is notable that each

of them had at least one male supporter to encourage her, to support her and to allow her to pursue her ideal and satisfy her passion while being perceived as an intruder in many circles.

What we learn from their lives is similar to what we see today, even if the social context has evolved and there are important differences between today and those distant times. As is still the case, these mathematicians had to use stratagems and creativity, and strategize to overcome certain barriers. They came up against closed doors and were not welcome in scientific circles. Young women attracted to STEM or pursuing careers in STEM today also face barriers, although not as extreme as the barriers or prohibitions faced by these three women mathematicians. This past is not so long ago and has left traces to the present day. Subtle (and very often unconscious) gestures or seemingly innocuous reflections expressed by their entourage are enough to make these women doubt themselves and think that they do not belong in a scientific or mathematical field. This feeling of inferiority may cause them to avoid mathematics, deny their attraction to the field, or use myths about mathematics to justify their failures or withdrawals, such as the notion that a special and superior talent is needed to succeed in mathematics.

9

ADVOCACY FOR AN ARCHIVE ON THE PLACE OF WOMEN IN STEM IN CANADA: AN ESSENTIAL TASK

"Where are the women in the history books?" "Do women have a story that could go down in history?" "Is a history of women conceivable?" Starting in the late 1960s, a growing number of feminists debated these questions in the context of the vigorous activism that was then permeating the women's movement in Canada. Their reflections demonstrated the existence of the marginalization, if not outright eviction, of women from the historical scene, whether as authentic subjects of history or as practitioners engaged in the development of a new field of historical research. An ambitious project took shape. It consisted in rewriting the "official" history dedicated to and written by men in order to integrate the life experiences of women who had been forgotten until then. However, it was first necessary to resurrect women's collective past, an essential step to give them back the visibility they had been deprived of. To a large extent, the "builders" of women's history shared and still share the conviction that the mobilizing potential of this field is real and that it is an integral part of the women's movement. Through teaching and research, these historians intend to carry out a rereading of women's past that would allow them to provide answers to the multiple questions of activists concerning the situation of women at present.

Although brief, this retrospective on the origins of women's history in Canada clarifies the context in which historical research on women in STEM is emerging. It is clear that STEM history lags far behind, if we think of the work done by working-class women, those in the so-called "feminine" professions and those in the more

liberal professions. How can this timid and belated interest be explained? At the turn of the 21st century, feminist historian Marianne G. Ainley (1990), a key pioneer in the development of a corpus of historical research on Canadian women scientists, explained this situation by invoking the influence of social history, which has focused primarily on the study of so-called "ordinary" women, as well as the recent development of the field of the history of science in Canada. But she also cited the critical lack of archival sources that could shed light on the personal and collective past of women in science and their contributions to these fields. At first glance, such a dearth seemed to confirm their marginalization and exclusion from this highly masculine universe. Yet Ainley's work and other recent studies of women in STEM show a very different reality, one which attests to the diversity of women's lives and experiences at the individual, disciplinary and institutional levels (Ainley, 2012; Millar & Wells, 2015).

In her study, released posthumously in 2012, Ainley recalls the difficulties in laying the groundwork for a history of women scientists due to the lack of personal records kept by women in science; but there was no doubt in her mind that they had done so because they undervalued the importance of these documents as historical material. Even more, they underestimated the value of their own contributions, an attitude undoubtedly shared – even encouraged – by their colleagues and superiors, not to mention the predominantly male archivists, who were primarily concerned with preserving and celebrating the legacy of male scientists.

These words were certainly a call to action for those interested in pursuing and promoting historical research on women in STEM. This call has been heard by an ever-growing number of institutions and organizations, groups and individuals who argue that increasing the representation of women in STEM requires a deep and diverse knowledge of their past. Writing this history would lift the veil on the challenges and obstacles encountered, but also on the successes and achievements that are too often neglected. This is why these stories are so important to girls and young women who aspire to a career in STEM and who are looking for role models to inspire them in their course of action.

The (re)discovery, processing and preservation of archival sources is an essential step in achieving these goals. In Canada, there was a demand to create national archives to ensure that women in STEM have a prominent place in the history of Canada. This initiative began in 2018, with the establishment of the Canadian Archive of Women in STEM (University of Ottawa, n.d.)[5]. Its goal is to become a centre of expertise in the documentation related to the history of women's contributions to these fields. For the first time in the country, information on the archival holdings of women in STEM in Canada will be brought together in one place and accessible in both English and French.

The Archive will support another core activity, the same one that Marianne G. Ainley advocated for, namely to encourage women in STEM to preserve their personal archival materials. They will be able to donate these materials to the Archives so that their experiences and contributions enrich research, increase knowledge, and produce female role models in these still too-male fields.

As activists, let us all rejoice together and contribute, each in our own way, to building the Canadian Archive of Women in STEM. We will then be able to give women the place they deserve in the history of STEM in Canada!

A WOMAN ENGAGED IN STEM

More than a scientist, I want to be
More than a mother, I want to be.

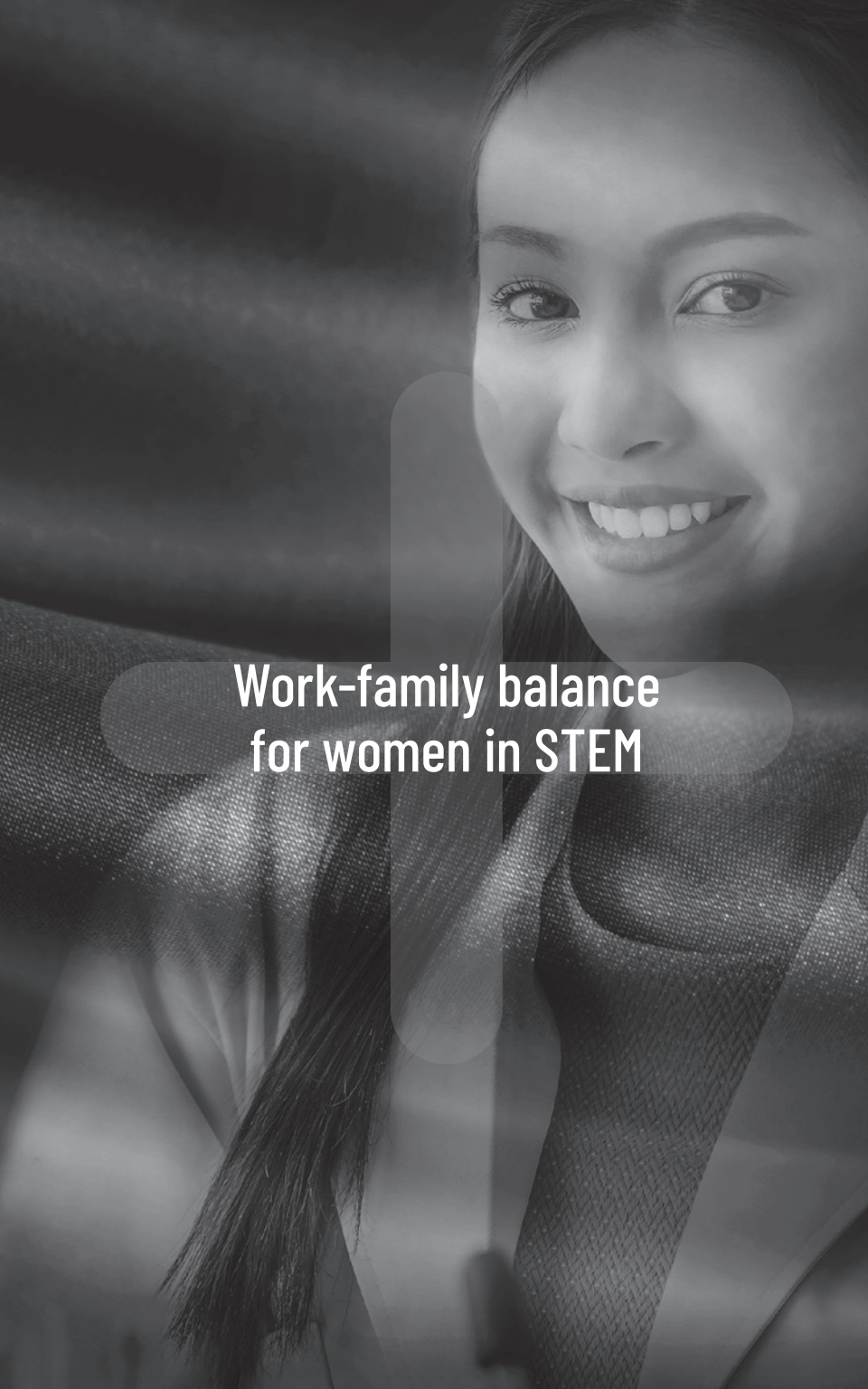
Scientist by pen or sword
Scientist of renown or lesser known
It's a jumble.

In the war, I shall hold my platoon
Brandish my weapon in front of the braggarts
I'll hit the fools
And I'll attack head-on.

Straight and fair, I will reach the heart of the wicked
I will succeed in unmasking the false kings of peace.
Good heavens, how good it will be
To defeat and kill evil.

Tyranny and piracy, I will resist
Iron cross, wooden cross
I shall have the star to which I am entitled.

Rise... it's time.



Work-family balance for women in STEM

10

WOMEN IN STEM FOR A MORE CREATIVE AND INNOVATIVE SOCIETY

> *"One is not born, but rather becomes, a woman".*
> Simone de Beauvoir

In just a few words, Simone de Beauvoir expressed the idea that gender is not biological, but a social construct. As gender is the result of a different socialization right from childhood, it leads to differences between women and men, particularly in terms of education and work.

From housewife to professional, the role of women in society has been gradually transformed. With the Parent Commission and the democratization of education in the 1960s, girls and women from all regions of Quebec were able to enter the school system and the job market. Despite these important changes, school and social structures, as well as the mentality that underlies them, have been slow to evolve. Women continue to face gender barriers, particularly in STEM fields, where men still dominate.

The idea that women are less competent than men in STEM fields, on the one hand, and that they are less interested in these fields, on the other, is still very prevalent, both in the job market and in family and school environments, as well as in society in general. However, this mentality is no longer as obvious as it once was. It has become more subtle and, as a result, more difficult to detect

and denounce. For instance, it would be inappropriate, if not impossible, to assert today that women become sterile if they get too involved with mathematics, claiming that an overworked brain would leave no room for reproduction. The fact that women are less represented than men in STEM fields is largely due to society, school and family "teaching" them, from childhood, that men are better in these areas. This education is done imperceptibly, for example, by giving more speaking time to boys and men in a variety of contexts (both academic and professional) or by suggesting that there are many obstacles to overcome, which may discourage some girls and women. It is of utmost importance to combat this gender hierarchy, especially in STEM

In contrast to this education, and in order to achieve greater equality of opportunity and representation of girls and women in STEM, it is important to value a diversity of voices, perspectives, interests and talents. Differences among people are essential in a creative and innovative society, and they must be valued for their positive impact on the community, education, the economy and in the fields of politics and research. These differences are beneficial to the job market and to the quality of decision-making in any company. Thus, in the same situation, women may look at things differently than men, since they do not have the same concerns or perspectives.

In a specific work context, here in the STEM fields, this complementarity allows a project to evolve differently, with more creativity and generating more innovation. A greater number of different situations will be considered, divergent questions asked, original and constructive answers given, and so on.

It is therefore important to collectively promote careers in STEM fields for women and show that their contributions are essential. They will then be able to make better career choices, first for themselves and then for society, which will reap the benefits.

Equity and equality in STEM for a creative and innovative society!

11

WORK-FAMILY BALANCE IN ORGANIZATIONS: A LONG WAY TO GO

Work-family balance (WFB) is a popular and concerning topic in our society. A study on women in traditionally male professions was carried out from 2016 to 2019 (Deschênes et al., 2019a). The results detail not only the main barriers to women's progression within these still predominantly male professions, including engineering, but also factors that facilitate their progression. Studies show that WFB remains the Achilles heel of these careers. In this regard, engineering is no exception: it remains difficult to combine family obligations with the performance expected in the workplace. Nevertheless, it is gratifying for the next generation of engineers to note that organizations are currently putting in place several measures, both in the private and public sectors, to facilitate the achievement of a balance between professional and personal obligations, particularly for women.

Work-family balance is a real issue for female engineers, especially in consulting engineering firms and in environments where certain tasks involve site supervision (Deschênes et al., 2019a). In order to adapt to these environments, women with children have to share tasks with their spouses and ask for support from the family or outside help. These women are also held back in their professions when it comes to geographic mobility: either it is impossible for them to progress in their careers because mobility requires complicated family accommodations, or opportunities for such displacement are simply not available to them because it is assumed that they will refuse them due to the complication of a balance between travelling and their parental obligations.

The organizations interviewed in the above-mentioned study are concerned about WFB. This is not surprising given their strong desire to attract and retain female engineers. These organizations are interested in meeting their workforce needs. To this end, they are interested in hiring and retaining female engineers, and ensuring that they have the same opportunities to progress as their male colleagues. They also recognize the particular contribution of women not only in human and relational terms, but also professionally. They therefore wish to achieve a certain parity between women and men. Consequently, each of the organizations we met had implemented (or was in the process of implementing) practices or policies to promote women, such as hiring equity, WFB and promotion to decision-making positions.

Thus, even if organizations remain committed to short-term performance, which takes precedence over other issues, such as WFB, their need for workers ensures that they implement measures to promote women's career progression.

A summary offered in the work of Brière (2019)[6] presents an approach that can help organizations move towards a better work-family balance. It is divided into four main stages. First, management must strongly express its commitment to WFB. It then undertakes and distributes an internal diagnosis of the situation, indicating the strengths and weaknesses of its equality practices. Next, it implements a suitable program to promote WFB before following up and sharing the results of the program with the staff. The program covers seven themes:

1. Adopting fair recruitment policies;
2. adapting work processes;
3. supporting staff promotion and specialization;
4. ensuring individual support for each employee;
5. establishing a good work climate and an EDI (equity, diversity, inclusion) climate;
6. promoting work-life balance;
7. Implementing good working conditions.

Each theme addresses several issues. For example, in connection with the sixth topic, which deals with work-life balance, three types of measures need to be strengthened: policies for the formal application of sick leave, parental leave and leave for caregivers; mechanisms for initiating (i.e., replacement) and returning from leave; and support services for employee assistance networks and collective measures.

Some of these measures are currently being developed and put in practice in several organizations. In the near future, it will be interesting to analyze the results and measure the career advancement of women in STEM following their implementation.

12

WORK-FAMILY BALANCE: MOTHERHOOD FOR WOMEN IN STEM

The employment world is becoming increasingly competitive and performance-oriented. Jobs are becoming more and more precarious for younger generations. In the perpetual struggle to carve out a place for themselves, women are often forced to postpone motherhood in order to invest more in their careers (Pacaut, Laplante, & Le Bourdais, 2006). In other words, these women face a difficult choice between motherhood and career (Cicchelli, 2001; De Wit & Ravanera, 1998).

Many young women feel uneasy about their desire to have children. This discomfort reflects the continuing influence of stereotypes about women, whether they choose to stay at home, postpone motherhood, or balance career and family, all of which are legitimate choices.

Motherhood is one of the most important challenges young women in STEM face. In fact, they are confronted with a dual identity, their family identity and their career identity, which they must assume in one way or another (Garner & Méda, 2006). This is particularly true for those engaged in long-term studies, who will have to undergo a double transition (Daigle, 2013). On the one hand, women who are still studying or recently graduated are struggling to find a place for themselves in the labor market and secure a promising future. On the other, these young women are at the age when they want to start a family. They are studying, preparing for or entering the job market during this period when their "biological clock" is ticking (Tamburri, 2013). For those who have already had a first child, a double transition is required: coming to terms with

both their new role as mothers (Cicchelli, 2001) and their role as students or young professionals, roles that are equally demanding. Unfortunately, many of them mistakenly believe that balancing these two roles is unattainable. Criticisms, such as wanting to have it all, are often directed at mothers who are climbing the career ladder. In other words, being a good mother and being successful in your career is living in a dream. However, there are many examples of women who succeed, often in spite of difficult circumstances.

Maternity, and the challenges it poses in the employment world, is a key element in the persistent inequality of career opportunities and requires careful analysis. On the one hand, women demand to be treated equally, especially in terms of advancement in an organization; on the other, there is an indisputable difference when it comes to having children. In the case of traditional motherhood, women carry the child. They are usually the ones who interrupt their careers or reduce their working hours to take care of their children in the first months of their life (Pacaut, Laplante, & Le Bourdais, 2006; Pailhé & Solaz, 2006, 2007). Those new mothers who choose not to stay at home may feel guilty. This happens due to the fact that, among other hypotheses, they feel more responsible for the baby than their spouse (Deschênes, 2005).

However, there are advantages to being a mother while studying or working. In particular, having a family provides an additional motivation to complete one's studies – in order to improve one's living conditions. It also contributes to success in both the professional and family spheres (Tanguay, 2014). Socially speaking, women's contribution to the labour market is also a guarantee of economic prosperity (The Economist, 2009). Thus, in order to achieve equal opportunity at work between women and men while promoting both family and economic well-being, it is necessary to offer women educational, professional, political and social conditions that take into consideration their possible dual role related to motherhood and career.

13

THE FEMALE REPRODUCTIVE SYSTEM: A KEY ELEMENT OF WORK-FAMILY BALANCE

Many women, whether they work in STEM or not, will want to have at least one child during their career. This is an absolutely personal decision that should not be used as a lever to pressure them to produce more or to maintain an absolute dedication to work. Some women will fulfill this desire early in their career while others may prefer to delay their first pregnancy to focus on developing their professional projects. These women may decide to freeze eggs for a future pregnancy. Some will face difficulties in procreation. In all cases, a proper knowledge of their reproductive system would allow them to make more enlightened decisions.

BRIEF SCIENTIFIC BACKGROUND

Nowadays, more and more studies are helping to understand the formation and functional development of future eggs. In the ovaries, each female gamete, called an oocyte, is part of a functional unit, the follicle. Its formation, folliculogenesis, begins before birth. In other words, a girl is born with a finite number of follicles which her reproductive health depends on. During childhood, follicle development ceases, then it starts again at puberty with each menstrual cycle. It continues until menopause, which occurs at around the age of 50, when there are far fewer follicles left in the ovary.

During folliculogenesis, the secretion of specific factors and hormones is crucial to maintain the female reproductive cycle. An imbalance in the secretion of these factors can affect the dynamics of the reproductive system and have consequences on the

physiological function of the ovaries (Pangas & Rajkovic, 2015; Richards, Liu, & Shimada, 2015). This results in various disorders, for instance, polycystic ovary syndrome (PCOS), which is characterized by a delay or discontinuation of the folliculogenesis process. Another consequence of early follicle depletion is premature ovarian failure (POF), observed at around age 40. Ovarian disorders can also arise from external sources. An example of this is endometriosis, which occurs when the tissue that lines the inside of the uterus (the endometrium) grows abnormally on the outside of other organs, including the ovaries, altering their physiological function. One out of ten women have PCOS (the incidence of this syndrome is highly underestimated according to Lujan, Chizen, & Pierson (2008)), one out of one hundred women 40 years old and younger experience premature ovarian failure (POF) (Cooper et al., 2011), and one out of ten women is affected by endometriosis (Singh et al., 2020).

Currently, women are usually only informed about these issues if they are experiencing infertility problems. If they had earlier access to this information, they could better manage the consequences of these pathologies (PCOS, POF, endometriosis), such as stomach aches, migraines and chronic fatigue, in their working lives. Women would experience less guilt at work and be less likely to be the victims of derogatory remarks from colleagues and supervisors, such as "she's in a bad mood, it must be that time of the month".

THE INFERTILITY CHALLENGE

Professional women, including those in STEM fields, should consider these factors in their career planning. Several associations[7] aim to make information about human reproductive function disorders available to the general public, but this information is often sparse, and insufficient in terms of the impact of delayed diagnoses (Gibson-Helm, Teede, Dunaif, & Dokras, 2016; Hager et al., 2019). For example, most women who fail to conceive naturally after a year of trying only receive a diagnosis (of endometriosis for instance) when they begin the process of assisted reproduction.

According to the Public Health Agency of Canada (2019), the number of couples with fertility problems has doubled in 30 years, affecting one in six couples in the country in 2019. In 1978, the birth of the first baby resulting from *in vitro* fertilization marked the beginning of a major scientific revolution in the field of infertility treatment since its causes can be both female and male. Moreover, women whose professional life is beginning to thrive may wish to develop their career and achieve financial stability before conceiving a child (Borovecki, Tozzo, Cerri & Caenazzo, 2018). However, after 35, women's fertility begins to decrease due to a decline in ovarian function and egg quality (Stoop, Cobo & Silber, 2014). This age-related decline has become a major concern for some women, who, for one reason or another, wish to delay motherhood. It should be noted that in Canada, more than half of all births are to women over the age of 30 (Canadian Fertility and Andrology Society, 2018).

Nowadays, the use of cryopreservation for non-medical purposes, also known as social egg freezing, is increasingly suggested to women of procreation age to preserve their eggs and this way postpone motherhood (Borovecki, Tozzo, Cerri, & Caenazzo, 2018). Until recently, this process was only suggested for medical purposes (cancer treatment, fertility disorders or egg donation), but this is no longer the case. An article in The Guardian (Tran, 2014) revealed that Facebook and Apple had announced they were offering their female employees $20,000 to freeze their eggs. This was perceived by the public in two different ways: one positive, as a way to give women more flexibility and relieve pressure and anxiety around parenthood; the other negative, as a device to create implicit pressure on women to fully focus on their work by delaying maternity (Borovecki, Tozzo, Cerri, & Caenazzo, 2018).

While the technical aspect of science is progressing to overcome infertility problems, social or family pressure is sometimes difficult to bear. Comments such as "So, when are the children coming?" or "Watch your biological clock!" are frequent. They are generally not uttered with hurtful intent, but they have a significant psychological impact in the current context, where infertility is still a taboo in our society.

Moreover, the means used for assisted reproduction depend on the cause of the infertility and the practices of the different clinics. One thing is certain: the hormonal treatments received by women who appeal to ovarian stimulation are uncomfortable, time-consuming and include risks.

THE REALITY OF YOUNG WOMEN IN STEM

The academic journey is demanding and often uncertain – and even more so for women in STEM fields. It can take more than 15 years to get a permanent position as a professor after graduating. In many cases, this period involves moving to another city or even another country. The pressure to be productive (obtaining grants, mentoring, and publishing scientific articles) can cause many women in STEM fields to postpone motherhood in order to achieve their career goals and financial stability. This delay has become possible through egg freezing, an option for deciding when to conceive, thus alleviating biological clock anxiety. However, egg cryopreservation is not an absolute guarantee of a future pregnancy. It remains a procedure requiring the use of assisted reproductive technologies, such as *in vitro* fertilization or embryo transfer. The rate of clinical pregnancies following an egg cryopreservation cycle varies from 2 to 38 percent, depending on the age of the woman (Borovecki, Tozzo, Cerri, & Caenazzo, 2018).

It would be wise to provide women with a professional environment that is considerably more sensitive to family and life choices, especially regarding maternity. This would benefit their development and success both in their careers and in society. In any case, a better knowledge of their own reproductive system would be an asset for women so that they can reconcile their professional and personal lives with more clarity, whether in STEM or in any other field. Furthermore, work-family balance is enhanced by the possibility of freezing eggs in order to delay maternity.

14

CONTRACEPTION AND ITS ROLE IN THE PROFESSIONAL LIVES OF WOMEN IN STEM

The majority of heterosexual couples of procreation age use contraception in order to delay their parental plans for various reasons (studies, work, etc.) or because they either do not want to have children at all or do not want to have more children. For a long time, the use of contraception was considered a criminal act under the Criminal Code of Canada. It was not legalized until July 1, 1969. On June 10, 1960, Ottawa approved use of the contraceptive pill in Canada, with the official goal of helping certain women regulate their menstrual cycle (Radio-Canada, 2020). Today, the Pill is one of the best known and most reliable forms of contraception, with over 99 percent effectiveness if used according to directions. It has given women the choice to plan their career and family life.

However, today, the contraceptive pill can be considered an environmental scourge, due to the release of some of its molecules into the water. In addition, women are increasingly turning to non-hormonal contraception methods (IUDs, sponge, cervical cap, diaphragm, spermicide, etc.). These are considered ecologically superior, but their effectiveness in preventing pregnancy is somewhat lower than that of the contraceptive pill. Scientific advances in female contraception in recent years have continued to improve the lives of women while trying to be mindful of ecological issues.

Contrary to popular belief, contraception is not just for women, and, for men, it is not limited to condoms. For years, scientific research has been evolving in the area of male contraception, and researchers have been working to find masculine alternatives to

female contraception. Vasectomies, which prevent sperm from reaching the penis, are one of the best-known male contraception methods, but there are others. In fact, there are currently different types of reversible male contraception that do not require surgery. An example of this is thermal contraception, with the so-called "heated underwear" method. This technique consists of raising the testicles' temperature to cause the death of spermatozoa, which cannot survive above 32°C, the temperature usually maintained in the testicles. However, this method is not yet recognized by the World Health Organization (WHO).

In contrast, hormonal male contraception has been available since 1978 (Schearer et al., 1978) and is approved by the WHO. It is less well known than its female counterpart and does not seem to be of much interest to the pharmaceutical industry at the moment (Universcience.tv, 2014). The most skeptical will allege that, unlike female hormonal contraception, whose effect is almost immediate, the male counterpart takes from one to three months to reach maximum effectiveness. This difference is explained by the 74-day cycle of sperm production (called spermatogenesis). However, pleading this difference to reject the pill for men seems more than anything to reveal the existence of the still very vivid prejudice that contraception is a woman's business. This raises two major societal and social questions: To what extent are men willing to adopt contraception other than condoms? To what extent are women willing to trust men with contraception?

Contraception poses at least three challenges for female scientists: 1) the desire, shared by many women in other careers, to choose when to conceive; 2) the appropriateness of engaging in socially significant research, such as egg freezing, contraceptive methods that are least damaging to women's health, and masculine contraception; and 3) a significant increase in the place of women in STEM within this research to ensure that feminist and female thinking is central to the process.


About women in STEM

15

WOMEN IN SCIENCE AND WOMEN IN PHILOSOPHY: A FIGHT LONG FOUGHT

It is interesting to recall that in the history of female mathematicians, Hypatia (360-415) and Émilie du Châtelet (1706-1749) have been referred to as both philosophers and mathematicians. Although these are two separate fields today, they do have a common feature: they are still predominantly male. In philosophy, women are a minority, as they are in STEM. Several challenges can ensue from this minority situation, such as having to demonstrate one's value and ability to reason, argue, and reveal one's critical thinking. Numerous women are cut off during discussions while trying to defend their ideas. If they express a point of view in an affirmative and determined way, they are described as aggressive. Furthermore, it is difficult to assert oneself as a feminist in these predominantly male environments. The root of the sexism experienced by women in philosophy is similar to that endured by women in STEM. Thus, women in the two fields express solidarity towards each other.

STEM's and philosophy's disciplines are similar, as they are both demanding when it comes to the abilities needed. They require, in particular, the mastery of a logical way of thinking that entails a strong propensity for methodical analysis and a search for objectivity. Both disciplines are primarily governed by reason, even though they both appeal to the affective and the social domains.

"Let no one ignorant of geometry enter" (Bénatouïl & El Murr, 2010, p. 68) was engraved above the door of the Academy, the philosophical school founded by Plato in Athens. It is said that the birth of philosophy, which marked the advent of rational and

scientific thought, occurred in these ancient times. Previously, human beings explained the world through mythology. A new form of thought gradually emerged and became, in modern times, the main source of legitimate truths and knowledge. Philosophy is often referred to as "the mother of all sciences" (Castelnérac, 2016) since it initially encompassed all intellectual disciplines governed by reason: medicine, mathematics, morality, geometry, astrology, and so on (Castelnérac & Fortin, 2014). The philosophical discipline thus laid the groundwork for a type of rational thinking that is so much in use today – in both the human and natural sciences – that we sometimes forget that it was not always that way and that the requirements of truth remain a human construct. Although the various scientific disciplines have gradually detached themselves from philosophy and become independent, philosophy remains their historical source.

Since these ancient thinkers, reason has been, with a few exceptions, theorized by philosophers as an essentially male faculty. This phenomenon is hidden behind a claim to universality, whereas it is a historical construct serving those who held – and still hold – the power. When philosophy met "modernity" during the Enlightenment, women continued to be presented as lacking understanding, voluntarily submitting to their husbands, not entitled to their own autonomy or to access to political life (Plaignaud, 2019).

It is through thought that claims to be neutral and truthful that many philosophers have also theorized the notion of "woman" as a weak being, devoid of reason, sensitive by nature and therefore dedicated to activities related to care (Tronto, 2008), that is to say, to the care of others and to concrete responses to the needs of others. For example, according to the traditional gender division (Tronto, 2008), historically speaking, women are defined by motherhood.

When women work outside the domestic sphere, they are usually nurses or nannies. Traditional Western philosophers have designated women as the Other, and men as the Universal, by excluding many people from knowledge through a chauvinist and sexist logic. In this binary system of thought, several tenacious dualities present notions as independent, even opposed to each other, for example: body versus mind, woman versus man, emotions versus reason.

On the one hand, there are men, endowed with reason, supposedly capable of abstracting themselves from their emotions, their corporality and their subjectivity, and claiming to rise to a higher level of the mind, the level of abstractions and impartiality. On the other hand, women are presented as beings incapable of reasoning properly, since they are dependent on what is sensed and experienced, prone to hysteria and act on intuition. Elements traditionally associated with men, such as rationality, strength, self-control and dominance, are valued, while elements traditionally associated with women, such as gentleness, emotion, passion and sensitivity, are much less appreciated. People whose gender identity does not correspond to the duality of woman and man (non-binary, genderfluid, etc.) and racialized people, to name but a few examples, are also excluded from the sphere of knowledge, or even pathologized since, in this Western tradition, the cisgender, heterosexual white male holds the monopoly on reason.

This perception of reason, which is now considered sexist, continues to taint our relationship to scientific thought, whether consciously or not. Even the most feminist women carry unconscious sexist biases and stereotypes within them. Everyone is still more or less influenced by these gender-binary thinking patterns. One of the struggles of intersectional feminism (Collins & Bilge, 2016) is to correct the epistemic injustices that women and people from marginalized groups suffer. A possible solution is to adopt a holistic way of thinking (hooks, 2019), a faculty possessed by a historically and culturally situated subject. It is time to discard the utopia of totally unbiased rational thinking and recognize that behind this appearance of objectivity lies subjectivity. Such a holistic view can also guide EDI (equity, diversity, and inclusion) committees in workplaces to increase the presence of women and people from marginalized groups and improve their conditions, particularly in the STEM fields.

It would be to women's advantage, both those in philosophy's and those in STEM, to tackle sexist and racist thinking by arguing that a person's sex, gender, and ethno-cultural origin have no bearing on their ability to reason and produce knowledge.

16

YES, MATHEMATICS ARE ACCESSIBLE, AND THERE IS NO TRICK![8]

The idea that mathematical problem solving is effortless is often unconsciously perpetuated by teachers, who magically find the solution very quickly. Typically, students look to their teachers as role models and want to emulate them. Generally, they are not conscious that the teacher has been teaching for many years, has solved these types of problems before, has learned and manipulated these concepts, and has certainly encountered these types of problems before. How can we tackle the belief that mathematics can only be practised using recipes or tricks?

This belief is tenacious. Learning mathematics is associated with two preconceptions, that of "trick" and that of speed. A magic act is bound to have a trick behind it, and if it is done fast enough, no one realizes what has happened. The perpetuation of this belief leads students to believe that knowing the "recipe" is essential to succeed in mathematics. This is reinforced by the exams they take, which often require more time than what is allotted. There is therefore a need to solve problems quickly or to finish exercises using the right trick. There is little room for reflection. And this idea of acting quickly in mathematics has a significant impact on learning, especially for girls, who feel rushed by this requirement.

Believing that in mathematics, as in magic, there is a "trick" or "recipe," students seek to master this technique (often through memorization), thus avoiding the use of their own mental processes – especially those related to comprehension – to solve a problem. Learning is limited to developing skills to solve similar problems. Even worse, it is as if the time allotted to thinking takes

away from the value of the solution found. The desire to solve a mathematical problem quickly is too often reinforced by teachers, who read a problem statement and immediately give the solution, as if it had sprung to mind spontaneously, without having to verbalize the intellectual process. Students then believe that, in order to gain speed in problem solving, they need to know the recipe.

To counteract these beliefs, it is necessary to propose complex problems that cannot be solved by following a recipe. For example, students can calculate the area of a room and various pieces of furniture to propose a layout for their room after a fictitious move. They keep a written record of how they solve the problem, which they then verbalize in order to compare it with their peers' and thus realize that the method was not chosen at random and that it required thought. If the problems proposed to the students are solved in too little time, they come to integrate the idea that the fast way is the only way, which does not correspond at all to the reality of mathematicians, male or female.

Problem solving is not unique to mathematics. Teachers, both men and women, could explain to both boys and girls that preparing a lesson requires thought and that finding a solution often takes many minutes, and in some cases hours. Using worksheets when solving problems and expressing frustration when seeking solutions are all situations that show the importance of reflection that can be presented to students in a positive way. This importance should not only be mentioned, but repeated, over and over. The usefulness of reflection can be demonstrated in a variety of situations, since this idea of a solution that arises spontaneously in the minds of adults is still strongly held by students. The point is to show that mathematics requires thinking and that the answers do not come quickly, to help young girls recognize that speed-based competition is not necessary in learning mathematics.

17

FUN AND SKILL FOR WOMEN IN ENGINEERING

Ironically, STEM fields are often associated with male professions and occupations. And yet, in many languages the word "science" is feminine and professions and occupations have no gender. Women and girls studying and working in engineering can have just as much fun as their male colleagues. And, most importantly, they are as competent as their male counterparts.

Women belong in engineering for many reasons; they are invested in what they do and are passionate about working in this field, for example. They enjoy finding solutions to existing problems, improving products, developing processes and creating innovative approaches. They value teamwork, which is often required in engineering, especially in mixed teams, because they make the work environment more natural and allow for a wider range of solutions to be proposed for the assigned projects. As they advance in their careers, women in engineering have the opportunity to manage projects. Engineering is a field that fosters a sense of belonging and purpose. It is clear that fun and skill go hand in hand for women in engineering.

Young women (but also young men) who enrol in engineering have not always dreamed of becoming engineers. One of the reasons for this is that they don't have a clear idea of what engineering work involves. They may also discover this field in a surprising way, somewhat by chance. For example, one young girl was introduced to physics, an important engineering discipline, through figure skating. She learned about the concept of centre of gravity and the importance of locating her own. Her interest in a career that was considered masculine became apparent while she practised her favourite sport,

considered typically feminine. Even today, despite advances in technology, the evolution of engineering work, and the many opportunities unknown until recently, girls continue to ignore the existence of this career choice and to discover engineering in all kinds of different ways.

The fact that women state that professions and occupations are genderless does not mean that everyone thinks so. Derogatory remarks are still made that imply that girls cannot do as well in engineering as boys, that they are unable to understand the content as well as the discipline itself because they are girls (and for no other reason). Many unfounded stereotypes abound in the field, such as "girls are not as handy as boys". Yet some girls, just like boys, operate machines skillfully, while some boys have difficulty with the fine manipulation of pliers. Likewise, gender has nothing to do with a person's engineering skills. The most important thing is to fight discrimination – by ignoring, countering or breaking these stereotypes. It is particularly important not to fear them and to pursue one's ambitions in order to show that the prejudices are unfounded.

Furthermore, since men still wield a great deal of power in the engineering world, the much-needed change in thinking for the cause of women must come at least in part through them. "It can have a powerful impact when men speak out for women's rights and challenge their own attitudes and behaviours, or those of others" (Engineers Canada, n.d.-b). In STEM, for example, many male colleagues now support the movement to counter stereotypes and prejudices about women. There are men who disapprove of sexist remarks and inappropriate gestures from their colleagues. Hearing different voices speak out against sexism in STEM provides hope for moving towards more equality and equity. Women and girls in engineering feel more supported and can pursue a career in engineering with pleasure and skill.

In engineering, gender equality has not yet been achieved – nor has equity – but the movement is under way. Women are not only taking their place, they are also increasingly happy to flourish in a field that, only yesterday, seemed inaccessible to them.

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FROM THE PROGRESS MADE BY WOMEN IN ENGINEERING IN MATTERS OF EQUITY AND DIVERSITY TO WHAT STILL NEEDS TO BE DONE

Female engineering students still experience inequality today, but they are generally unaware that a great deal has changed in the last 50 years. For example, in the 1960s and 1970s, it was difficult to find women's restrooms in engineering schools and faculties because there were so few female students. We have come a long way since then, but we still have a long way to go.

In the early 2010s, Engineers Canada set a national goal, "30 by 30" (Engineers Canada, n.d.-a). Engineers Canada decided to use a statistical quota that would stir people into action to set the course for achieving this goal by 2030 across Canada. Spelled out, the goal is "raising the percentage of newly licensed engineers who are women to 30 per cent by the year 2030" (Engineers Canada, n.d.-a). The national result as of December 31, 2019, was 18 percent and, more specifically, 16 percent in Quebec. Parity is far from being achieved and, for this reason, equity is still taking its sweet time.

Why is it so important to have more women in engineering schools?

Because everyone deserves the same opportunities to have big ambitions and to reach their full potential. A girl may dream of becoming an engineer and changing the world in her own way, while a boy may dream of a career in nursing or elementary school teaching to change the world in another way.

Because a critical mass of 30 percent allows a subgroup, in this case women in engineering, to reach a threshold of solidarity that favours its influence on the whole group. Reaching this threshold makes it possible to anticipate a lasting cultural change within the profession thanks to the increased presence of women.

Because it is recognized that companies with high levels of ethno-cultural and gender diversity are more likely to strive for equity and equality in the workplace (McKinsey & Company, 2020). Specifically, each individual is able to bring their personal background and experiences, vision, insights, and scientific expertise to the company, thereby fostering innovation and creativity. This inclusion of diversity improves the decision-making process and the adoption of diverse solutions.

Finally, because the current situation of the planet is critical: climate change, pandemics, famine, natural disasters and more. All scientific contributions are important. All expertise is essential to save our planet/home.

19

ARTISTIC CREATION IN MOVIES AND STEM, AN INSEPARABLE DUO

For years, there has been an undeniable and growing connection between the fields of art making and STEM. The STEM knowledge required to make certain artistic works sometimes goes unnoticed. To accomplish specific works of art, it is now imperative to master a wide variety of concepts in science, technology, engineering and mathematics.

In the creative arts fields, women and people from diverse backgrounds face the same issues that have long been identified in the STEM community. There is the same glass ceiling, the same boys' clubs, and the same systemic barriers, not to mention the fact that female creators have as much difficulty as women in STEM being recognized, hired, funded, featured in the media, recognized by academia, and included in associations related to their craft. It is only on rare occasions that these creators make history, receive prestigious awards, are called creative geniuses, or that their works are called masterpieces.

Yet, some of these female creators possess an immense knowledge and great skills that come from and belong to STEM. This knowledge and skill set go far beyond the use of technical tools. This is true of film professions, from cinematographer/director of photography to those dealing with colorization, animation, picture editing, sound editing and mixing, special effects, and so on. It is also true of works created in virtual reality, multimedia, interactive content, video games, and more.

Mastering the technical and technological aspects of cinematography requires a learning path that includes optical physics (lenses), chemistry (film), mathematics (calculating the quantity and temperature of light), and electrical physics (charge balance and electrical circuits in lighting). It is necessary to be comfortable with the logarithmic scale, with the calculation of distances for focus and depth of field, with calculations to predict the position of the sun at a given time, with the use of a light metre, a colorimeter, an inclinometer, a multimeter, a gyroscope (for image stabilizers), a vectorscope, an oscilloscope, and lookup tables (LUTs), to give just a glimpse of the breadth of knowledge and skills required in the creative field of filmmaking.

Cameras have become highly sophisticated and programmable computers. The data collected during a shoot requires knowledge of digital data management software for post-production. Post-production requires supervising the photography department to transform the image until its final presentation/result. Thus, there will be the stages of colorization, special effects and digital intermediaries for those who shoot using film. Some related jobs, which require collaboration with the director of photography, also require a mastery of STEM notions. These include lighting technicians, who use notions of physics (optics, electricity, etc.), and stagehands, who rely on physics and engineering.

All of these professions and concepts combine to create works that enrich culture, whether through films, interactive sculptures, multimedia tours or virtual reality. The scientific sphere is honoured, as evidenced by the existence of the Academy of Motion Picture Arts and Sciences, which gives out annual Academy Awards (the Oscars) to recognize excellence in the field. The same Academy also gives out Scientific & Technical Awards to recognize individuals and companies whose discoveries and innovations make a significant and lasting contribution to the film industry.

Unfortunately, female creators who use STEM tend to stay in the shadows of their art, remaining essentially separate from the field, when they could benefit from the knowledge, support and networks

for advancement built by and for the STEM community. Indeed, these creators often find themselves isolated and without resources in their creative niches. As a result, too few female photography directors are successfully making their mark. In 2017, only nine percent of photography directors in television in Canada were women. None of them were from a visible minority or had an Indigenous background. In film, only seven percent of cinematographers were women, one percent of whom were visible minority women. None of them were Indigenous (Women in View, 2019).

These problematic situations begin early, in educational institutions where programs sometimes fail to provide an inclusive learning environment. Often, workshops and creative exercises using new technologies in fine arts are not gender-balanced. For example, boys often handle the tools while girls do the other tasks – similar to what happens in STEM training. This is especially problematic because educational institutions have yet to institute concrete changes to address the recommendations made by the *Dimensions: equity, diversity, and inclusion Canada* charter (Social Sciences and Humanities Research Council of Canada, Natural Sciences and Engineering Research Council of Canada, and Canadian Institutes of Health Research, 2019). Another related issue is that there is no dedicated training program for directors of photography in Canada. A female creator needs to take more than one training program to acquire the knowledge and develop the skills required for creative work involving (new) technologies.

The recommendations in the report produced by Women in View (2019) are clear: specific, measurable, and public goals must be established, and results must be reported. There is a need for inclusive and gender-sensitive measures, as the status quo is no longer an option. It is time to recognize the knowledge of female creators, support them, hire them and fund their work on an equal basis with men.

20

NURSES ARE WOMEN OF SCIENCE

Nursing has not always been considered a scientific discipline. Terms such as "nursemaid" or "nursing care" contribute to debates about the foundations of the nursing profession; especially since, in Canada, it is rarely classified as a natural and applied science (Government of Canada, 2021a). This has led many to ask: is nursing part of the "sciences"?

As While (2021) observes, the term "science" is used universally for all scientific disciplines, although it is defined from different angles. In addition, the type of work is the basic principle that guides the classification of occupations in Canada (Government of Canada, 2021a). This principle may differ from country to country or may not reflect the scientific basis of the discipline it represents.

The practice of nursing began more than 2,000 years ago, right around the time of Hippocrates (Theofanidis & Sapountzi-Krepia, 2015). It developed through the contributions of many women, including Florence Nightingale (1820-1910), known for her contributions to the care of the wounded in the Crimean War (1853-1856), and the recognition of nursing as a profession (Gregory, Patrick, Raymond-Seniuk, & Stephens, 2019; Grypma, 2018). The evolution of nursing has also seen advances related to the development of theories and research evidence that guide professional practice. Indeed, nursing is defined as both an art and a science, encompassing relational and evidence-based components, respectively. These components are constructed from four types of nursing knowledge: empirical, ethical, personal and esthetic

(Carper, 1978; Fawcett Watson, Neuman, Walker, & Fitzpatrick, 2001; Norman & Ryrie, 2009). Nurses (men and women) use this knowledge to work with patients, families and communities in a collaborative approach with other members of the health-care team. With this body of knowledge, nursing has established itself as a scientific discipline. It is not surprising that the term "nursing care" has been replaced by "nursing sciences" in university education.

Like Florence Nightingale, nurses work hard to use their nursing knowledge to meet the needs of the people, sacrificing personal and family time during epidemics such as SARS, Ebola virus and the current COVID-19 pandemic. They are on the front lines of various health sectors at all times, but their vital role is even more visible in times of health emergencies. Praise and thanks have recently been expressed from around the world to all health professionals, especially nurses (Clark, 2020). Yet debates about the scientific basis of nursing persist (While, 2021). The extent of nursing knowledge appears to be unknown to the public, despite its benefits for all. It is important to promote and value this knowledge so that nursing care truly becomes nursing sciences on an international scale and is considered a scientific discipline in its own right.

21

MINING: AN INDUSTRY REMAKING ITSELF TO GIVE WOMEN THEIR RIGHTFUL PLACE

The mining industry has long been a traditionally male workplace. Over the years, women have slowly but surely carved out their place in this industry. These pioneers have contributed to a positive transformation by creating a more inclusive environment. And now, the presence of women in mining is growing.

Mining companies have generally paid attention to women's complaints and even protests. This has contributed to changes in facilities, procedures and, consequently, the daily lives of women working in the mining sector. These companies have made this possible by soliciting women's input regarding changes that need to be made, among other things. This is a positive and successful approach that could be implemented in other areas.

One of these important implemented measures is to provide new recruits with a better support network by holding meetings during their first few weeks on the job. Since this integration period is critical for retention, they also administer satisfaction questionnaires – which contain specific questions for women who join predominantly male teams. Consulting with women in this way makes it possible to create and easily implement an action plan developed in collaboration with these new partners. This supports the application of successful action strategies and egalitarian practices in the industry. Although women are still a minority group in the mining industry, their presence increased by 36 percent from 2014 to 2018. For example, in direct employment, it increased

from 11 to 13 percent. However, retaining women employed in the mining industry still remains a problem. Here are some examples of measures instituted over the years.

OFFERING APPROPRIATE WORK TOOLS AND A HARMONIOUS ENVIRONMENT, PROVIDING WOMEN WITH CLOTHING THAT FITS THEIR BODY SHAPE AND PROPER PROTECTIVE EQUIPMENT AND FACILITIES

The arrival of female recruits to the profession and in production positions has brought the development of new ways of performing tasks, which are gradually being recognized as safer by company management. Facilities and equipment, originally designed for male workers, are now adapted to female workers. Whether it is clothing or protective equipment adapted to the female body type, sanitary facilities or accommodation, workplaces are being outfitted to be more inclusive and safer for all workers.

INNOVATING IN TERMS OF PERSONAL, FAMILY AND PROFESSIONAL LIFE BALANCE

In some training centres, particularly those for aboriginal communities, student residences that can accommodate all family members are planned and even filled once built. The challenge of balancing work and family responsibilities is becoming an increasingly important part of all workers' lives. In the mining sector, tough schedules and remote sites, some accessible only by air, present particular organizational challenges, especially for those with parental responsibilities. The measures already in place to support the reconciliation of family, personal life and professional responsibilities offer advantages that contribute not only to attracting people to work in this particular field, but also to retaining them while promoting their well-being. Many mining companies cover the gap between salary and government allowance to increase the income of employees on parental leave. Many companies are implementing accessible and effective communication methods that allow employees to easily reach their families in the event of an emergency.

INVITING WOMEN TO APPLY FOR DECISION-MAKING POSITIONS AND TO COMMIT TO THEM

Women's leadership programs are also widespread within the industry, and all qualified women candidates are encouraged to apply for decision-making positions when they become available. There is no doubt that women have been able to carve out their own path and make their mark in an industry that might be mistakenly thought to be male-only. While the traditional professions welcome women who have been able to stand out, the transformation that is currently taking place in the mining industry suggests that their numbers will increase as more and more women enrol in mining training programs. The face of the mining sector has changed dramatically over the years, particularly in the ways in which it promotes equity and parity. Greater representation of women will certainly have a positive impact on the history of mining in Quebec.

22

THE UNKNOWN SIDE OF WOMEN ENGINEERS' CAREER DEVELOPMENT

Women are poorly represented in engineering. In 2018-2019, they constituted 15 percent of the Ordre des ingénieurs du Québec membership (2017). However, according to a recent qualitative multidisciplinary study conducted in Quebec, engineering is overall a favourable profession for women (Deschênes et al., 2019a). Interview analyses reveal that the female engineers consulted value the characteristics of the profession, including the problem-solving approach and teamwork. The more experienced ones note a significant change in the environment over the past 20 years. However, the participants all expressed the idea that many challenges remain. It is worth mentioning that the sample did not include women who had left the profession and did not present an intersectional analysis.

According to Deschênes and her colleagues (2019a), women who choose engineering in college have a strong interest in the science sector. They believe that science allows them to contribute to society, protect the environment and build a better world. Once they leave school, new female engineers generally have no difficulty finding work in their profession. Their hiring is currently favoured because many companies have realized that a balanced gender representation can confer an economic advantage. These companies attribute better interpersonal skills, attention to detail and organizational skills to women. Once hired, the female engineers interviewed come to appreciate the teamwork and gender mix, which provide a broader view of problems and encourage the development of a wider range of solutions.

It is important to mention that the majority of women consulted have noticed a change in attitude in the engineering environment: they perceive relations with their male colleagues as generally positive and less sexist than in the past, especially when it comes to office work, which accounts for a majority.

However, being women, these engineers face several challenges. For example, if they manage to balance their family obligations with their work, it is not always easy: they often rely on a spouse, a family member or a caregiver to achieve this balance, as the parental and personal leave available is rarely sufficient. Some of the female engineers interviewed confided that they receive sexist comments from older people and that, if they are young, it is still difficult to gain respect on construction sites today. Unfortunately, the fact that young female engineers sometimes have to work harder than men to demonstrate their skills and learn the profession is still a reality.

To meet these challenges, these female engineers are adapting to the environment by asserting their professional identity and femininity in their own way. They use the same strategies as their elders: dress neutrally, joke around, address inappropriate comments on the spot, and, as a last resort, ask for the intervention of a superior. Some of the women interviewed decided to embrace their femininity, wearing pink construction boots, for example, or to use it to their advantage, benefiting from some of the gender biases currently prevalent in the engineering community that favour women.

There is great potential for career advancement for women in engineering. Decision-making positions are increasingly accessible to them, and companies are making sure to offer them opportunities to progress. However, the conditions they encounter are not always favourable. One of the characteristics of the profession is that access to positions of responsibility often requires that applicants abandon the technical aspects of the profession to move into administrative positions, which is not suitable for everyone. In addition, this sometimes requires geographical mobility, which is more difficult for women than for men in terms of family life.

Despite the obstacles that still stand in the way of career progression for women in engineering, including the difficult work-family balance, sexism in the field, and mobility issues, the study still concludes that the engineering profession is a good fit for women (Brière, 2019)[9]. The most negative conclusion from the study relates to the underrepresentation of women in engineering. The most positive relates to the type of work to be performed, that is to say solving technical, social, and environmental problems. Women involved in the study particularly appreciate working in a diverse, multidisciplinary team.

Overall, the female engineers interviewed have a sense of self-satisfaction but still face challenges in achieving full recognition. The status of women in engineering is on the rise, but still requires changes in organizational practices if women are to one day have equal and equitable careers in engineering.

23

FOR A FEMALE MODEL OF DIGITAL INCLUSION

Today, more than ever, it is important to reduce the digital gender divide, particularly in the face of an explosion of disruptive technologies and in a pandemic context that requires remote work (Yagoubi, 2020). According to the Organisation for Economic Co-operation and Development (OECD), the acceleration of digital transformation increases uncertainty and makes the dynamics of change more complex: indeed, one must "explore and prepare for a range of alternative future scenarios" (OECD, 2018a, p. 19). In terms of jobs (acknowledging that massive job loss cannot be predicted), the OECD estimates that nearly 15 percent of current jobs are likely to disappear due to automation over the next 15 to 20 years. In addition, the tasks associated with more than 30 percent of the remaining jobs could be greatly altered (OECD, 2019).

highly valued in the labour market (OECD, 2018b). Natural sciences and engineering graduates, who often have good ICT skills, as well as those trained in ICT, accounted for only 23 percent of OECD graduates in 2015. What's more, within this group, there are significant differences between women and men. The OECD's finding is alarming: ICT skills account for the largest income inequalities between women and men (OECD, 2018b). Data collected over the past decade has shown that Japan has the largest wage gap (over 25%). Canada has a gap of about 15 percent, France's is approximately 10 percent, while Denmark's is around 7 percent. Turkey has the lowest rate of wage inequality for ICT skills, at 5 percent.

These inequalities have a social and economic impact (OECD, 2018b). This is why, in the face of these findings, it is in countries' best interests to work together to strengthen girls' digital literacy by ensuring digital mediation in all spheres (in the family environment, at school and in extracurricular activities). Organizing this requires the commitment of public authorities, the education sector and associations to ensure a network that allows a real social program. It is important that the ambassadors of women in technology promote the empowerment associated with them and encourage young women to pursue careers in STEM, particularly in technology.

A good model to adopt to foster women's digital inclusion is the acronym EL'TECH[10]:

- **E**mpowerment: Aiming for legal, economic, and social equity.
- **L**eadership: Aiming for encouraging women in technology and encouraging networking.
- **T**echnologies: Aiming for digital equity and attracting women to technology fields.
- **E**ntrepreneurship: Aiming for entrepreneurial equity, such as including more women in start-ups.
- **C**reativity: Aiming for and fostering the development of creativity.
- **H**oned skills: Aiming to develop the expertise and know-how related to women's digital literacy, in addition to developing an emancipated relationship with technology.

The adoption of such a model would allow various organizations to discuss issues related to the attraction and retention of women in technology fields, but also to implement innovative solutions that would increase the presence of women, particularly in the innovation technology sectors and in the training offered by engineering schools.

24

FOR A BETTER REPRESENTATION OF WOMEN IN ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is becoming more and more important in our daily lives. It is used, for example, during Internet searches and by software programs trying to complete words when someone is writing an email. The number and variety of tasks that are better performed by machines than by humans is constantly growing. These tasks are also becoming more complex. Governments are investing more and more in AI research as they recognize these undeniable advances and the strong potential for important innovations for society.

What will a society where AI takes a prominent place in human activity look like? On the one hand, such a society would offer several advantages. For example, in medicine, diagnoses made by intelligent machines are likely more accurate and reliable than human judgment (Harari, 2017). Such machines would be available at all times, they would have access to the entirety of scientific knowledge, and they would have computational capabilities far beyond those of the general practitioner.

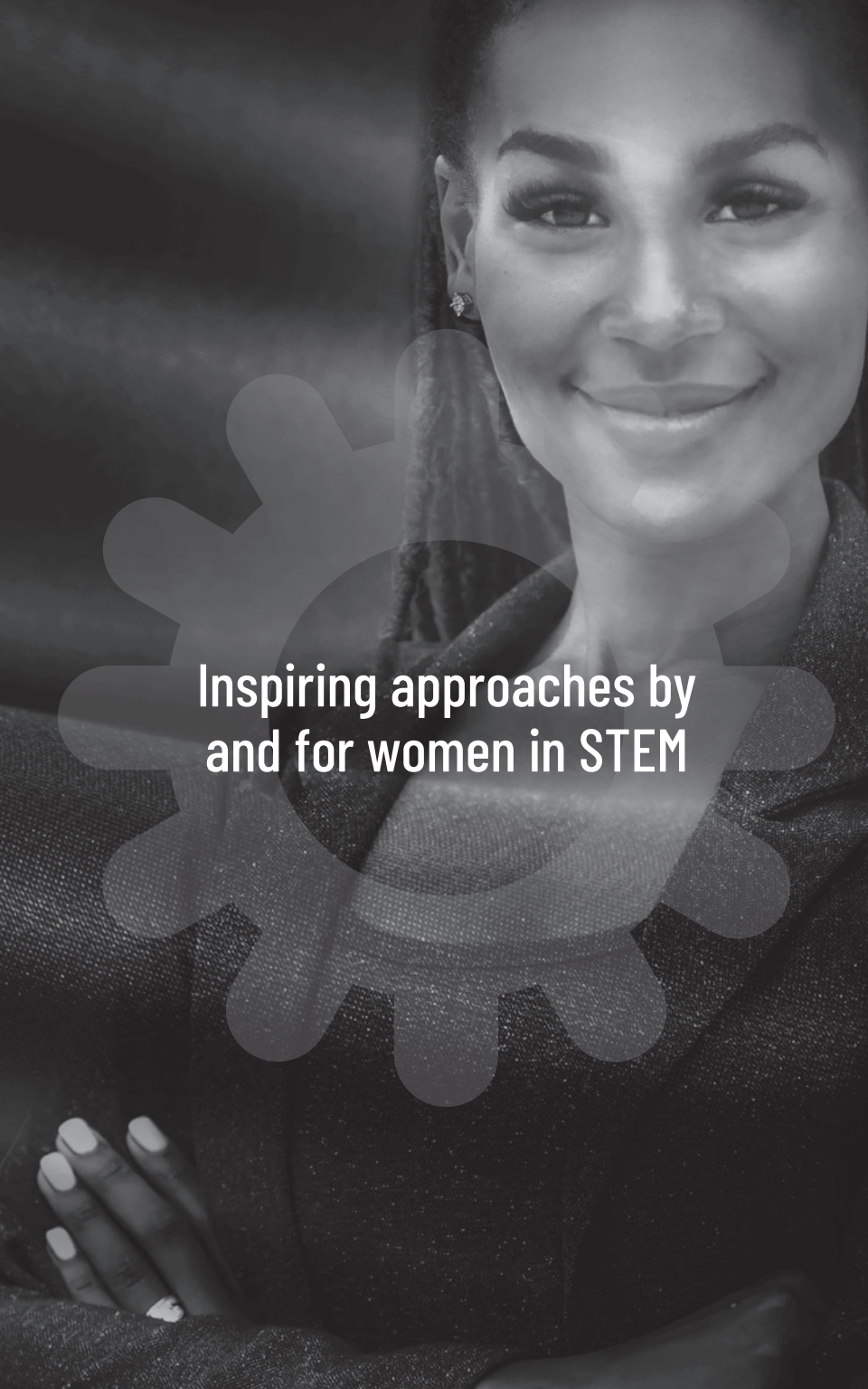
On the other hand, artificial intelligence poses a significant threat to societal balance when only 20 percent of information technology professionals and 12 percent of AI researchers are women (TECHNOCompetencies, 2018). This imbalance leaves women on the sidelines when it comes to responsibility, influence and power. Indeed, companies that already control AI have increased control over society. Women, underrepresented in the research labs of these powerful companies (and therefore also in the vast field of AI), are thus left out of this societal change.

Ideally, the problem should be solved at its source – in other words, by increasing the proportion of women in university programs designed for high-tech careers, such as computer science, engineering, mathematics and physics, all of which are in some way related to AI. This is a tall order, since the fraction of women enrolled in these fields has been stagnant – even declining since the early 2000s in the United States, whereas it had been steadily increasing before[11]. The statistics available in Canada and Quebec are similar to those observed in the United States. According to the Ministry of Higher Education and Scientific Research in Quebec (Ministère de l'Enseignement supérieur, de la Recherche et de la Science, 2015), at the college level, 52 percent of graduate students in science programs (particularly in the natural sciences) are women. However, bachelor's degree enrolments were approximately 20 percent in physics, 15 percent in computer science, and 10 percent in computer engineering (Chaire pour les femmes en sciences et en génie au Québec, 2017), and remained relatively constant during the 2005-2011 period (Ministère de l'Économie, de la Science et de l'Innovation, 2016b, 2016a).

How is it possible that these leading fields still have not achieved parity, when it has been proven that women's abilities in these fields are equal to those of men (Frize, 2009; Rippon, 2019)? When pondering this complex issue, it is important to note, on the one hand, the still pervasive influence of often stereotypical representations emerging from the cultural and societal universe and, on the other, the influence of family and the social environment and the responsibility of the education environment in the construction of professional identity.

Finally, some more pernicious dangers have been well documented in the past, such as the fact that some algorithms develop biased images of men and women (Simonite, 2017).

Adopting an intersectional feminist perspective could help counteract biases in data science practice (D'Ignazio & Klein, 2020). This perspective needs to be better known, taught in university science and engineering faculties, and promoted in workplaces.


Inspiring approaches by
and for women in STEM

25

FOR GLOBAL ENGAGEMENT IN STEM: INTERNATIONAL GIRL'S DAY AND ADA LOVELACE DAY!

Some people may think that the situation of women and girls in STEM is no longer an issue, that it is steadily improving, and that raising awareness about gender equality in these fields is no longer necessary. However, this phenomenon of inequality is present in many countries, to such an extent that international days have been established to remind us of the background and current situation of women in different fields, STEM included. These days point out that, despite the efforts made and the progress achieved, there is nothing to indicate that the time has come to slow down the push for gender equality in STEM. Representation, stereotypes and prejudices are taking a long time to change; and several of the initiatives that have been implemented are not showing concrete results for the time being.

In 2011, Canada proposed the creation of the International Day of the Girl Child, to be celebrated every year on October 11. The United Nations proclaimed it on November 19, 2011, with the aim of encouraging improved opportunities for girls and raising awareness in all countries about the inequalities that many women still suffer today, including a lack of access to education and health care, violence, discrimination and forced marriage. Every year, the United Nations Children's Fund (UNICEF) hosts a campaign on this day to give girls the opportunity to have their voices heard and to mobilize for their rights. The theme chosen by UNICEF in 2020 was "My voice, our equal future" (United Nations, 2020).

The United Nations International Day of the Girl website notes that "Progress for adolescent girls has not kept pace with the realities they face today, and COVID-19 has reinforced many of these gaps" (United Nations, 2020). It also states that, currently, worldwide, nearly one in four adolescent girls aged 15 to 19 is not employed, in school or in training, compared with one in ten boys. In 2021, some 435 million women and girls worldwide struggled to survive on less than $1.90 a day, including 47 million who will fall into extreme financial poverty as a result of COVID-19. Prior to the pandemic, estimates showed that one in three women experienced violence in her lifetime, and signs point to an increase. Each year, 12 million girls under the age of 18 are married, often against their will, and 130 million girls are still out of school.

In STEM, the main obstacles revolve around discrimination and unequal access to education. There is an underrepresentation of female STEM students compared with male students, and young professional women face various forms of discrimination that limit their success in the labour market. In response, Ada Lovelace Day (2021), celebrated on the second Tuesday of October, was inaugurated. This day honours Ada Lovelace, an English 19th-century mathematician (1815-1852) who is credited with being the first computer programmer, as she wrote the first algorithm to be used by a machine. This day aims to honour women in science to inspire young women of today to follow their example.

Many young women around the world do not have access to school or higher education. If there are fewer and fewer of them in STEM as they progress through the educational levels, how will we benefit from their contributions? Whether or not they achieve global prominence, all women in STEM remain a manifestation of social progress in educational access, equality and equity. Special events like International Day of the Girl Child and Ada Lovelace Day are great opportunities to honour women who have influenced STEM, which would look very different without their contributions[12].

26

IT *IS* POSSIBLE TO BE PASSIONATE ABOUT MATHEMATICS![13]

Someone passionate about mathematics finds pleasure in playing with numbers and geometric figures, without necessarily looking for the purpose of the discipline. They continuously let their mathematical thoughts float around giving them the same feeling as reading a good novel or playing a video game. They do mathematics anywhere and all the time: outside of school, on public transportation, while walking, dreaming mathematics dreams and waking up with a valid solution…

According to the dictionary, passion is a very intense emotional phenomenon that can lead a person to forget about everything else. Young people or adults can develop a lasting passion for mathematics that can become permanent. Elementary and high school students, both boys and girls, also experience moments of passion that foster their appreciation.

This passion can lead to two types of reactions. The first is a reaction of pleasure experienced in doing mathematics. This is linked to a feeling of satisfaction, for example, the contentment a person feels upon finding the solution to a problem. This pleasure translates into a kind of well-being experienced during the activity. A person who feels this pleasure often expresses it through their appreciation of the discipline, in words and through gestures, and by their level of commitment to the task, evidenced by the amount of time, energy and effort invested and the desire to engage in this passion. The level of commitment is directly proportional to the interest in

the task to achieve. When it is strong, the person will not be discouraged by a failure to find the solution quickly but will instead fully commit to their search.

As in any passion, a second reaction is possible: frustration, when the object of the passion is out of reach. If the goal of the activity is to find a satisfactory solution and this seems impossible, it often leads to frustration. This feeling is temporary, but it takes over the mind and interferes with reasoning. People passionate about mathematics can also experience a certain form of frustration associated with being misunderstood by others who do not fully understand their passion. And they may also feel performance anxiety with regard to this discipline. Although girls experience this more than boys do, it does not mean that boys are immune to it (Lafortune & Solar, 2003).

A passion for mathematics is often associated with being considered a "math whiz" or having the famous "math bug," thought to be innate. Even so, this passion is not always synonymous of success by academic standards. Some people love mathematics without necessarily achieving exceptional results in a school context. Conversely, being passionate about mathematics is not a condition for success in this field.

Biographies of people who are passionate about mathematics could be used as a discussion starter to delve into this debate in the classroom. This could be complemented by students searching the Internet for biographies of people who are passionate about other STEM fields. In addition, researching women passionate about different STEM fields can provide role models for young girls who are attracted to or have questions about these disciplines.

27

IT *IS* POSSIBLE TO BE PASSIONATE ABOUT TECHNOLOGY!

The technology world is still predominantly male. Therefore, it is important to demonstrate the creative and social side of this field to encourage teenage girls and young women in college and university to pursue careers related to this world.

Here is the story of Samia[14], a teenage girl who, out of curiosity, decided to join the robotics club of her public school. She made this decision despite the lack of encouragement from her parents: "But come on, Samia, what are you going to do with robots? That's not you!" However, as soon as she arrived at the club, she really enjoyed the activities. She was already very involved in extracurricular activities, but this time she really felt like she belonged as she discovered a real passion for technology. This first awakening was only the beginning of a long series of revelations. Thus, to claim that girls lack interest in technology as a way to explain their reduced numbers in this field is a mere excuse that is hard to justify. It would be better to attract young girls to this field, by debunking the many prejudices and stereotypes that can block their path. They need to know that they are needed in these technology-related fields and that they belong there.

Samia stood out, and she was consulted on the organization of two events aimed at giving teenage girls the chance to meet women in the technology field. Her involvement in these events allowed her to encourage other young girls to participate in various technology-related activities. Samia's enthusiasm and commitment became contagious. Developing a passion can have repercussions beyond

one's personal interests, and the desire to share it can go viral. The result of young women encouraging others to choose and get involved in the STEM field is often very impactful.

In addition, Samia decided to volunteer at an event for college and university women. She also got involved as a participant in various technology events. She furthermore agreed to post her profile on an Instagram page (Concertation Montréal, 2021b) to inspire other young girls like her. While pursuing a science degree in college, she improved her self-esteem and perseverance; and her involvement led her to discover a great passion for technology. It is fascinating to see all the doors that have opened for this teenager and the passion she developed for technology. It all started with simply participating in a robotics activity!

Samia's experience is inspirational; it will certainly contribute to changing the way teenage girls and young women view technology. This clearly demonstrates the need to provide girls with committed female STEM role models, not only to inspire them but also to fight against prejudices and stereotypes, and to encourage them to pursue a career in technology!

28

GIRLS IN DISADVANTAGED ENVIRONMENTS: TAKING ACTION TO INTEREST THEM IN STEM

It is vital to introduce science to girls from disadvantaged environments in order to develop their interest. Studying in STEM fields not only lets them escape from poverty through access to well-paid jobs; in addition, it opens up a world of knowledge that gives girls a sense of empowerment and self-worth. Furthermore, jobs held by women are often more stereotypical in these environments, and female role models in STEM are less common. It is therefore essential to present girls with female role models in science with whom they can identify so they can project themselves into the future and imagine holding such positions.

Programs and activities promoting STEM to girls from disadvantaged environments[15] aim to help them develop various cross-disciplinary skills and, more importantly, provide them with inspiring and interesting experiences to learn about various STEM fields. This can also help counteract school dropout and poverty among women.

Finding ways to attract and sustain girls' interest in STEM is essential. Here are some outcomes of projects for young girls in disadvantaged areas.

ACT EARLY AND OVER SEVERAL YEARS

Apparently, Quebecers' interest in science, as taught in school, decreases between the 5th grade and the end of high school, and this is slightly more pronounced in girls than in boys (Potvin &

Hasni, 2014). Consequently, it is important to act early in girls' lives, when they are naturally curious and enthusiastic. At the end of grades 4 and 6, certain preconceived notions about these disciplines begin to crystallize. Thus, it is important to propose activities that target mainly girls in these grades, before their minds are made up. Indeed, 14- and 15-year-old girls often do not know which field they wish to study, but they already have a long list of what they do not want to do. Acting at younger ages and pursuing these interventions over the long term increases the probability of making a lasting impact and thus encouraging girls to choose STEM fields in college and university.

METHODS TO GET GIRLS INVOLVED

Some of the methods suggested may seem trivial, but they are beneficial in a disadvantaged environment. They help to nourish the body and the mind, to motivate girls' interest and to keep them involved. In the context of extracurricular activities, this means, for example:

- Picking up girls after school;
- Giving them a nutritious snack;
- Building meaningful connections between facilitators and participants;
- Promoting diversity and inclusion within a girls' space.

GIRL-FRIENDLY TEACHING METHODS IN STIMULATING MOMENTS OF LEARNING

- Using a playful approach that promotes girls' active participation;
- Offering a variety of activities (varied sciences, programming over a few years);
- Hosting guest lectures from a variety of scientific fields;

- Organizing visits to knowledge centres (museums, universities, laboratories, companies, etc.);
- Implementing programs "by and for" girls, where they are involved in developing and orienting activities.

Leaders of a program that has run for the past 30 years to encourage girls from disadvantaged backgrounds to choose to study and perhaps work in STEM fields asked themselves whether the activities carried out had had a long-term impact[16]. Some of the thousands of girls who participated stayed for only a few months, but the majority participated for several years. The testimonies of former participants clearly show that this type of program had a direct impact on their thirst for knowledge, their desire to develop it and the pleasure they take in doing so, and their motivation to persevere.

The adventure continues, but more than ever in 2021, the efforts to interest girls from disadvantaged environments in science must be intensified as society cannot deprive itself of their contributions to scientific and technological progress.

29

INCLUSIVE AND EQUITABLE STRATEGIES IN EDUCATION FOR A BETTER BALANCE BETWEEN WOMEN AND MEN IN THE SOCIETY OF THE FUTURE

Research in education shows that girls will consider a career in science less than boys will. Tackling this difference may seem like a monumental task, as many factors influence the construction of a "scientist identity" and the interest of young girls in science. Indeed, it depends on, among other things, cultural background, family environment, and teaching methods (Fils-Aimé, 2011; Hasni & Potvin, 2015). Fortunately, identity is malleable. After the crucial role of parents, teachers have the most influence on young people's identity. Moreover, research in education shows that certain attitudes or teaching strategies support the development of a scientific identity in young women (Fines-Neuschild, forthcoming; Hazari, Sonnert, Sadler, & Shanahan, 2010; Parker, Pelletier, & Croft, 2019).

Examples of strategies include:

- Discussing the problem of women's underrepresentation in STEM fields.
- Discussing job-related opportunities in computer science, mathematics, physics and engineering, especially jobs that are beneficial to society (e.g., those related to the environment, health, social causes, and so on).

- Conducting direct recruitment, i.e., advising young women who show an aptitude and interest in these fields to select advanced courses or enrol in a bachelor's degree in one of these disciplines. This strategy is particularly important as it deals directly with the sense of self-efficacy, which is an individual's belief in their ability to perform a task and is, on average, lower in young women than in young men.
- Reducing marginalization in the classroom: distributing attention equally and ensuring, for example, that everyone will handle the lab equipment (avoiding the typical situation where a male teammate performs the experiment while his female teammate takes notes).
- Recognizing young women's skills by providing encouragement and praise for their abilities to succeed.

If a majority of science, computer science, and mathematics teachers in Quebec adopted such inclusive and equitable strategies, it would be possible to have a real impact on the underrepresentation of women in STEM. This would ensure a more just society of the future, taking into account diversity among gender, ethnic and cultural background, economic situation, sexual orientation, etc. These strategies for orienting girls and women to STEM can be integrated with those currently in use, possibly requiring minor adjustments. One thing is certain: they should be put into widespread use, because they have a positive and long-term influence on the educational and career choices of girls and women.

Finally, it is much more efficient, from a logistical point of view, to work directly with teachers, as they are often involved with several student cohorts. A number of solutions have been implemented for teachers since the mid-1990s in Quebec[17]. What remains to be done is to ensure that these activities are sustainable, adequately funded and promoted to as many teachers as possible.

30

CREATING INCLUSIVE, INNOVATIVE AND INSPIRING RESOURCES IN STEM

Many science promotion organizations are looking for solutions to increase young girls' interest in science and engineering. To make these disciplines more appealing, some occasionally incorporate female stereotypes, believing that pink, glitter, high-heeled shoes, makeup and perfume will make a difference and entice girls to choose a STEM major. This is generally not a good approach, as these themes offer too narrow and stereotypical a representation of girls and their interests. As an example, *The Guardian* referred to the "Science, it's a girl thing" ad campaign launched in 2012 by the European Commission as "a viral fiasco" (Rice, 2012). These themes do not match the reality of the field, focusing too much on artifice and lacking content. Furthermore, it is unhealthy to ask young girls to fit all the models of beauty and femininity in addition to being smart and successful in STEM.

The example of the "Science, it's a girl thing" campaign clearly illustrates the challenges of creating advertising campaigns and providing resources or activities to increase girls' interest in STEM while avoiding stereotyping. It is complicated to propose new opportunities without generating resistance or reaction when confronted with such preconceived notions. In addition, a certain amount of tact is required to avoid the propagation of stereotypes, which are sometimes unconsciously conveyed.

The general population does not have a very good grasp of STEM fields. The stereotypes surrounding them are not always gender-based but are related to work environment, interests and personality traits. They may even be different depending on the

culture of the environment. Not only women and girls, but everyone, would benefit from better information. This would help people understand the STEM fields, get a more accurate picture of the environment, and grasp women's and girls' interest in engaging in it or being reluctance to do so. The idea is not just to create girls-only resources or activities but to ensure that they are not excluded and that they feel challenged as much as boys do.

It goes without saying that creating such inclusive resources is a challenge. For this reason, the following principles are used to guide the development of these projects.

USE KEY MESSAGES THAT FOCUS ON EFFORT AND SKILL DEVELOPMENT WITH A POSITIVE MINDSET

Instead of emphasizing intelligence, talent or ease, messages could focus on perseverance, learning and experiences. In addition, they could be accompanied by reflective questions about the evolution of skills.

Example of comments:

It was hard and time-consuming work, but you persevered and succeeded. You should be proud of yourself; you gained experience in this project. Great job! I noticed that you experimented with different strategies.

Examples of questions:

- What did you learn from completing this project?
- What are the strengths and weaknesses of your work?
- What could you reuse in another project?

INCLUDE SCIENTIFIC CONCEPTS IN HUMAN, SOCIAL AND TECHNICAL CONTEXTS.

Most of the time, carefully selected contexts, such as human biology, health, and the environment, might be of interest to a broader audience. However, others with a more technical content can also be enticing. The idea is to vary them.

Examples of situations to propose:

Illustrate the concepts of pressure and pump in the human heart (physiological context) and in a mechanical pump (technical context); represent the moments of force using the inclination of the neck (physiological context) and when building an inclined tower (technical context).

Examples of questions to ask when explaining scientific concepts:

- What is human and social in the problem being studied?
- What falls under the technical dimension in the problem studied?
- How is each dimension important?

EMPHASIZE COLLABORATION AND MUTUAL AID AS LEARNING MODES

To foster the development of necessary STEM competencies (such as problem solving), resources should emphasize collaborative learning rather than individual or competitive learning.

Examples of practices to implement:

- Encourage the exchange of perspectives on observed phenomena or problems to be solved;
- Prioritize team experimentation in the search for solutions, discussion of results, analysis of a situation or preparation of a report.

Examples of questions related to collaborative learning:

- What did you learn in this collaborative work?
- What did you learn that would have been difficult to discover on your own?

SHOW A VARIETY OF FEMALE SCIENTIFIC ROLE MODELS

It is important to show accessible female role models with different profiles, varied interests, diverse personality traits, and challenging career paths so that young girls can easily identify with them and project themselves into a science career.

Examples of practices to implement:

Highlight admirable traits (perseverance, drive, resourcefulness, etc.), varied concerns (making a difference in the world, improving people's quality of life, finding solutions to protect the environment, overcoming obstacles and challenges, etc.), values (respect, honesty, equality, etc.), dreams and passions.

Sample thought-provoking questions:

- What are the characteristics of successful people in STEM?
- What qualities do you think you have?
- How would these qualities help you succeed in STEM?

TAKE DIVERSITY AND INTERSECTIONALITY INTO CONSIDERATION

Activities and resources could take into consideration diversity and individual differences (ethnicity, gender, socioeconomic background, sexual orientation) that young women may present so that they feel challenged and included in any project.

Examples of practices to implement:

- Adding subtitles to videos to reduce language barriers and hearing issues;
- Holding activities in locations that are accessible for people with limited mobility;

- Showing models from different ethnic and cultural backgrounds;
- Embracing inclusive writing;
- Adapting scenarios to geographic realities;
- Choosing realistic photos or images that are free of stereotypes.

Sample thought-provoking questions:

- What seems most realistic to you in the activities presented?
- What seems unrealistic to you in the activities presented?
- How could the activities be changed to better represent your own reality?

Even with these guidelines for inspiring and innovative new STEM resources, the implementation of inappropriate activities is still possible. It is important to question yourself often and to query each other among colleagues to avoid unconscious bias and ensure that you are portraying a realistic picture of STEM. Another excellent way to improve and validate the resources produced is to consult with people from other fields for advice, review, or even external evaluation. These could be experts in STEM, education, outreach, and equity/diversity/inclusion, people from diverse backgrounds, and young people, both girls and boys. Considering all these dimensions is not always easy, and creating resources based on these principles requires a lot of thought and time. However, it is necessary in order to ensure the quality of the activities and increase their impact.

Creating quality content that is free of stereotypes and prejudices that convey misleading images of STEM education and work is a great way to inspire the next generation and move towards greater equity, diversity and inclusion!

31

THE ESSENTIAL CONTRIBUTION OF THE STEM STUDENT COMMUNITY

STEM students, both women and men, play an important role in shifting mindsets towards a more just and diverse future for the field. These young people have often seen their mothers pursue careers and their fathers become increasingly involved in household and family chores. They have been encouraged by school to pursue careers that suit them. They have discussed sexism, homophobia, transphobia, racism, equity, diversity, and inclusion at home, with their friends, and at school. They aspire to live in a world where everyone can feel fulfilled in their own way. Not surprisingly, their contributions to changing the way women are viewed in STEM are visible and add momentum to discussions and actions.

Here are some examples of individual and collective initiatives[18] that are already under way in Quebec:

- Welcoming activities: A group of students is organizing welcoming activities to promote the integration of women into STEM programs. These include back-to-school events, which may include testimonials from women working in the field, for example.
- Science and technology outreach activities: These activities are usually lectures on the status of women in STEM, but also company visits, science field days at the university, networking meetings, and so on.

- Outreach and recruitment activities for future students in STEM: These involve visits to high schools, CEGEPs and colleges to present not only role models of women in STEM, but also the diversity of possible careers and the skills that can be developed in the field.
- Teacher education activities: As stated in this *Manifesto*, teachers play a prominent role in guiding girls into STEM or any other field. Therefore, some targeted activities benefit from speaking directly to members of that profession.
- Introduction-to-research internships: Graduate students organize internships to introduce high school students to research. For a few days, the students shadow young researchers in their daily activities and can carry out their own short research project.
- Peer mentoring: Peer mentoring is a form of mentoring between students who are more advanced in their STEM studies and novices.
- Participation in institutional committees: Some student organizations have been successful in obtaining a seat on one of the institutional committees or creating new ones.

Hopefully, the activities proposed by the student community will continue to change mindsets and spread to various settings, including outside of academia.

32

PHILOSOPHY AND MATHEMATICS: A PROMISING ALLIANCE

Philosophizing about mathematics with young people in preschool, elementary and secondary school[19] is an original and promising idea that aims to develop critical and creative thinking. It promotes the expression of good judgment not only in mathematics, but also in science and other areas of life.

This pedagogical vision of philosophy involves a social and interpersonal learning process that promotes the overall development of the learner. Young people ask themselves philosophical-mathematical questions such as "Is my room a cube or does it look like a cube?" or "What is the beauty of mathematics?" or "Can girls, as well as boys, succeed in mathematics?" For example, in the second case, they could discuss philosophically the beauty and usefulness of mathematics, but also its advantages, limitations and social contribution. Young people thus become philosophers of science. As early as elementary school, children develop critical thinking skills and formulate solid arguments that make both parents and teachers think (Daniel, Lafortune, Pallascio, & Sykes, 1996a, 1996b, 1996c). Becoming a philosopher of science helps to reduce the negative impacts of young people's emotional reactions to mathematics; it decreases their anxiety and increases their self-confidence, especially for young girls (Lafortune, Mongeau, Daniel, & Pallascio, 2002a, 2002b).

Getting young people to philosophize about mathematics requires training that is integrated within the teaching of mathematics (Roy, 2005). By targeting teacher education directly, both teaching teams and student groups are trained to philosophize about mathematics.

Discussion forums that include virtual communities of philosophical-mathematical research organized around pedagogical-philosophical questions chosen by university students contribute to this training (Roy, 2016; Roy, Deschênes, Boisclair-Châteauvert, & Simard, 2014; Roy, Lechasseur, & Michel, 2016).

Philosophizing about mathematics focuses on constructing meaning to engage both young people and teaching teams. Asking questions of philosophical and pedagogical significance prompts deep reflection, peer discussion, and the search for meaning and diverse solutions (Daniel, Lafortune, Pallascio, & Sykes, 1996a, 1996b, 1996c). The term "philosophically oriented discussions" (PADs) indicates that the philosophical aspect of the discussion builds as the dialogue proceeds within a community of philosophical inquiry, as opposed to a juxtaposition of ideas. Teacher teams and student groups learn to draw on the ideas of others to build on them, improve them, challenge them, or construct new ones together and thus contribute to the group's thinking. This implies an openness to the ideas of others and a possible self-criticism of one's own, rather than a posture of confrontation, which breaks the dialogue.

The philosophical research community is a central element of the association between philosophy and mathematics[20]. It promotes cooperation and contributes to the development of the cognitive, affective and social dimensions of learners and teachers. In this context, two fundamental principles must be respected. First, learning involves a personal construction of meaning, and second, intrinsic motivation is essential to learning.

The first principle materializes as a reflective process of research among peers around philosophical concepts related to mathematical themes or notions. First of all, an initial individual reflection brings out one's own thinking, which can be partly questioned by and with peers. The second principle helps learners make meaningful connections between mathematical activities and their daily experience, as well as between their thinking and that of others. It also encourages the reinvestment of skills developed in other contexts. Associating philosophy and mathematics implies revisiting

pedagogical practices in science, technology and mathematics to promote a reflective culture in the classroom (Pallarès, Hausberger, & Roy, 2021)[21].

Philosophy and mathematics seem to form a promising alliance to foster greater reflexivity and critical thinking in mathematics among girls and women in STEM, which helps them to develop more confidence. Indeed, girls and women's participation in philosophically oriented discussions in mathematics appears to be particularly beneficial for them. These discussions train them through praxis, namely, through reflective activity that focuses not only on intellectual development but also on habits rooted in experience.

In teacher training, practicum seminars or community workshops are an innovative way to create greater socio-pedagogical equity within the school. Indeed, students are part of society in their own right and bring to the classroom their personal, family and social backgrounds, which they share in their own way. Taking them into account contributes to building a more equitable society.

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WORK AND FAMILY PLANNING BALANCE: AWARENESS, SUPPORT, AND GROWTH FOR WOMEN IN STEM

Developing a career in STEM is not always easy. To thrive in this field, women could benefit from workplace education and mentoring programs on career development, fertility, family planning and work-family balance, among other topics. Tools explored in these programs would help them better balance all aspects of their personal and professional lives and encourage more of them to choose these professions and stay in them.

Over the course of their lives, women face difficult choices. Many are concerned about both their career choices and whether or not to have children. They have to grapple with their "biological clock," which restricts their ability to bear children. Others have to deal with pathologies or syndromes such as premature ovarian failure, endometriosis or polycystic ovary syndrome, which can have an impact not only on their reproductive health, but also on their personal and professional quality of life. And yet, young women often lack knowledge about these issues. If they were better informed about such complex issues as biological fertility and family planning, they would be able to choose the appropriate time to have children and make enlightened choices about their career paths.

The use of methods to safely delay childbearing, such as assisted reproductive technologies (ART) or egg freezing, has increased. It is important, however, that these options be discussed. The choice to delay having children is extremely personal and should not be imposed on women in any field, but particularly in STEM, as their careers are generally built when they are of childbearing age. The various contraceptive methods available, including male

contraception, should be made more accessible to women, favouring free and informed choices. Information should be supported with scientific arguments and explanations.

Gender inequalities persist in academic positions in Canada. For example, female STEM professors in universities still represent a minority. According to Engineers Canada (2020), in 2019, 17 percent of engineering faculty members were women. Policies in Canadian universities must be changed to increase this percentage significantly. Currently, the years when women face the highest scientific productivity demands often correspond to the years when their reproductive capacities are at their best. Additionally, women who enter academic careers face difficult choices between their professional future and their family life. Good mentoring programs could support them in their decisions to maintain a balanced lifestyle. They would benefit from knowing the options and strategies available for career development in Canadian universities. For example, government policies to regulate parental leave, which have been implemented in the federal public service of Canada, could be an inspiration to universities that do not yet have such policies to promote work-family balance. Moreover, family planning should be integrated into education during the early years of women and men's reproductive lives.

It is therefore becoming essential for women working in STEM to be aware of research advances in the field of reproduction. Mentoring programs that focus on balancing careers and family planning, together with a feminist approach to fertility control, would give women more control over their fertility and career paths. Society has a relevant role to play in helping women take charge of their reproductive lives without feeling guilty about it.

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HOW MENTORING FAVOURS A LEVELLED PLAYING FIELD FOR WOMEN IN STEM

STEM jobs are generally well paid and are perceived as prestigious. However, they are characterized by a gender imbalance, which is greater in North America than in some other countries, such as Venezuela, Tunisia and Myanmar (UNESCO, 2019). One of the means used to foster greater equity and certain equality is mentoring. How would this mentoring attract women to STEM careers and encourage them to stay in them?

Like women working in other male-dominated sectors, those who choose STEM too often do so without any guidance. They face invisible but exhausting obstacles. For example, they experience microaggression (Parker, Pelletier, & Croft, 2019), which is unconscious, unintentional comments or gestures that may seem harmless but, over time, affect women's scientific orientations. They can lead to career changes, lack of self-confidence and low self-esteem. Without organizational support, the resilience of many women reaches a breaking point. Mentoring can thus become an activity that promotes respect for the other in diversity.

Informal mentoring often develops naturally among group members. Unfortunately, one of its often-unintended outcomes is the exclusion of those who perceive themselves or are perceived as different from others, such as women in STEM fields. In contrast, an organizational mentoring program that is sensitive to inclusion and equity democratizes opportunities for all. Those who are not part of the majority group or who do not have access to the informal network are not left out. Moreover, when it comes to discrimination, well-trained mentors help mentees distinguish between what

is their personal responsibility and what is the responsibility of the institution or the community. Furthermore, mentoring breaks down isolation and empowers women by clarifying what they can change, and what they do and do not have power over.

These statements are supported by several studies. Results from a meta-analysis (Mickey, 2019) of female academic researchers highlight how informal networks are more effective than formal announcements in learning about job opportunities, inviting people to collaborate on research projects, and creating connections with government and industry. They are also used to exchange ideas about projects and to raise the profile of their members. Women, particularly those who belong to a less visible minority (one of the populations in this study), are often excluded from powerful networks in male-dominated settings such as STEM. Hence, mentoring is intended to enable female researchers to better integrate their communities, be recognized by them and perform in them. In addition, it increases women's presence in leadership positions, allows them to develop professionally and personally, and helps to close the gender pay gap (Adams, Steiner, & Wiedinmyer, 2016).

Dennehy and Dasgupta (2017) carried out a study on female engineering students after they finished their first year of study. They reported that 11% of those without a mentor had dropped out of their studies, while those with a mentor were just as engaged in their studies as they were at the beginning of the year. In addition, a survey of female engineers conducted by the Ontario Society of Professional Engineers (2018) found that the top two barriers to professional development for those participating were lack of respect and appreciation in the workplace (45% female vs. 20% male) and lack of role models or mentors (45% female vs. 19% male).

In sum, mentoring is a solution that fosters the presence and retention of women in STEM. When mentors are well trained, they help change the culture of an organization, or even an entire field, so that all people can thrive and achieve their full potential.

A HEARTFELT PLEA: A LETTER TO PARENTS, GRANDPARENTS AND SOCIETY AT LARGE

First of all, have faith
Let us live our childhood!
Games, creativity, mimicking
Let us be and we will get there.

We become adults by using our imagination:
Drawing, miming and counting numbers.
We believe the moon and stars dance
In our dreams, the moon and planets think.
Then, we become specialists in astrophysics,
In astronomy, we become astronauts or math geniuses.

Encourage our compassion for healing
Let us use your tools in safety
Walk with us through the discovery of everything inside
Even if it is to demolish a construction. We dare…
Everyone knows that STEM requires curiosity
and its wonders have no boundaries.

Learn to be on watch! To pay attention!
We fervently beg you,
Not to try to impose on us your frustrated dreams
Your vain and false pride, old-fashioned
As well as your gratified accomplishments.
Let us choose our colours.
Stop repeating the same rules
Rather, give us a sign!
Your nagging hurts our ears,
And blocks our understanding.

In adolescence, our hormones intrigue,
Shock, annoy and make us tired.
They are rather a source of energy
Of strength, of creation and of sweet madness.
We demand real models:
We vividly demand them.
We refuse to be supervised
But we accept accompaniment.
What precedes, we think about it,
We strongly desire what comes next.
Here you are the reasons why we grumble
The ones that made our protest.
We demand, not in vain.
We demand, not to awake paternalist emotions.

We demand, not to express our failures.
We demand, not because we do not like to work.
We demand, not to plant subversive ideas.
We demand, not to support injustice.
We demand, not to encourage negative outcomes.
We demand, not to beat the drums of war.
We demand, not to reinvent ourselves.
No! No! No! We are already invented.

We demand access to real education.
We demand not needing to avoid obstacles and pitfalls.
We demand our rights to STEM careers.
We demand the right to professional ethics,
In hiring, job attribution and staffing ratios.
We demand a fair and equitable salary.
We demand work-family balance.
We demand our right to go out into the world
To contribute to its development; we are not made in bronze.
We demand the right to claim a leave

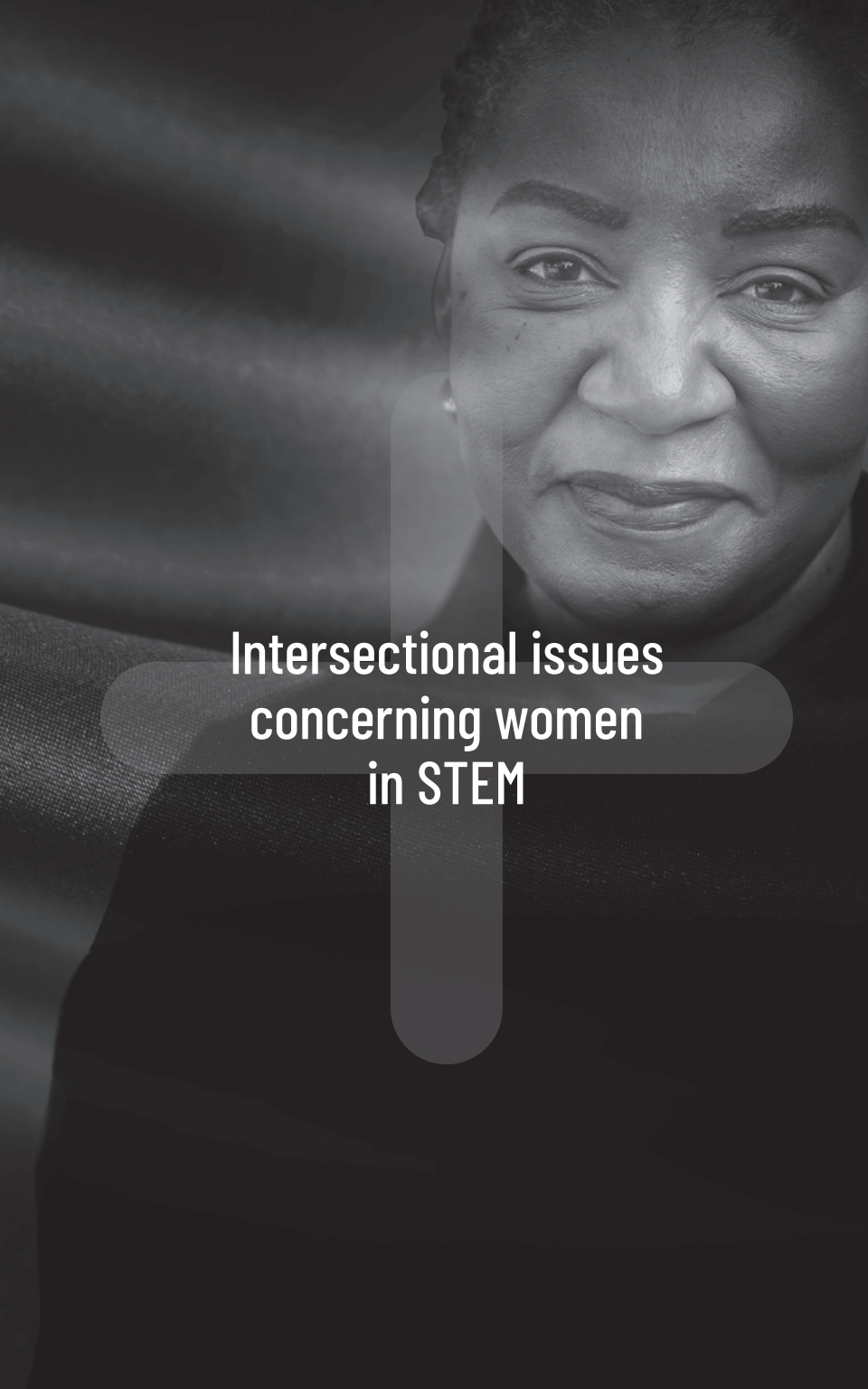
And to rediscover a career we didn't abandon due to maternity.
We demand because we want human and professional equity
We believe in it.
We demand because we have the certainty
That, on earth, 50 percent of the human population
Is different, but complementary to the other 50 percent.
We demand because what we write makes sense.
We demand because our purpose is understandable.
We demand to be able to get out of men's shadow.
We are part of the universe of creation and science.

Should we publish comics about girls and women
That decide to engage in STEM?
Make stand-up comedy about STEM?
Write a rap song to shake out the existing stupor?

Or sing the Blues of girls and women in STEM?
Who will take the stage to explain STEM?

Time is passing and things have to get better.
It has to change, and it's urgent!

Together, we will do it!



Intersectional issues concerning women in STEM

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ON THE IMPORTANCE OF CONSIDERING INTERSECTIONALITY IN STEM

In 1989, legal scholar Kimberlé Crenshaw introduced the concept of intersectionality in an effort to define the intersection of sexism and racism experienced by African American women. This concept refers to a social reality that some people endure when they experience multiple forms of discrimination simultaneously (Janssen, 2017), such as those associated with gender, ethnic and cultural background, socioeconomic status, sexual orientation, or various disabilities. Moreover, it is nowadays acknowledged that being at the intersection of two or more forms of discrimination has greater consequences than the sum of the effects of each form of discrimination (Bachand, 2014).

In some ways, Crenshaw (1989) also highlighted that being a woman is not a single experience, but rather one moulded by the various features of this identity. For example, a young girl from a large family in Gaspé and an only child from Colombia who recently immigrated to Montreal will have life courses influenced by their gender, ethnic origin, mother tongue, family context, living environment, socioeconomic background, etc.

The STEM field would therefore benefit from considering the diversity of identities and the intersection of forms of discrimination to move towards a more diverse, inclusive and equitable environment. It is essential to create the conditions for all girls and women to be safe, physically and psychologically. This will help them feel more included, give them easier access to inspiring role models and allow them to benefit from mentoring and sponsorship. There are

multiple goals women seek to attain. First, to feel that their presence is appreciated, that their work is relevant and that their contributions are recognized. Also, to ensure that their fields of interest, concerns and perceptions are taken into account. Finally, to be confident that the challenges they face are taken into consideration and that the differences among them and between them and the majority do not harm them.

If we focus on higher education and research, we can see a positive movement in these types of institutions. Gender-based violence training is now mandatory, and awareness of unconscious bias and the potential benefits of diversity are becoming more common, giving rise to some awareness. Equity, diversity, and inclusion (EDI) requirements of some research granting agencies also require applicants to think about the challenges that members of their future research teams may face. Today, academic institutions are strengthening their efforts to hire more female faculty members. Many student groups also value diversity. And Engineers Canada has adopted a national goal of having 30 percent of newly licensed female engineers in Canada by 2030. The provincial professional associations have decided to join this initiative (Engineers Canada, n.d.-a).

Although the above examples are necessary and encouraging, few policies, projects and actions address intersectionality. However, several initiatives are already leading the way and making a positive impact. This is the case, for example, of an inclusive teaching approach being developed, from elementary school onwards, that pays particular attention to language, interactions with and between the students, situational scenarios, activities offered, and so on.

Joy Buolamwini, MIT Media Lab computer scientist, who founded the Algorithmic Justice League, has a very interesting take on the topic. She explains how artificial intelligence can increase discrimination against marginalized people. In a popular TED Talk (Buolamwini, 2016), she points out that the effectiveness of facial recognition software decreases dramatically when the image being processed changes from a male face to a female face, and from a pale-skinned face to a darker-skinned one. She offers a series of

recommendations (attempting to identify algorithm biases, creating diverse datasets for training artificial intelligence algorithms, etc.) that share a common aim to combat these biases.

At the same time, Smith (2019) released a report in which she condemned the underrepresentation of marginalized groups (Indigenous men, visible minority men, women, Indigenous women, visible minority women) in leadership positions (deans, in particular) at major Canadian universities. It specifically calls on universities to review their practices to encourage greater diversity in their leadership.

Overall, while girls and women make up just over 50 percent of the Canadian population, they are not a homogeneous group. In other words, one woman's story does not represent all women. Moreover, for many, the path to the same opportunities is more tortuous and fraught with obstacles. Thus, in order to integrate more women and foster inclusion and equity for them, the STEM field has to self-evaluate and work with the results. Furthermore, it has the responsibility to apply an equitable, diverse, inclusive, and intersectional approach across the entire chain of actions. These have to go from igniting girls' interest in STEM and moving women into leadership positions, to academic recruitment and job retention.

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EQUITY, DIVERSITY AND INCLUSION (EDI) TO PAVE THE WAY FOR WOMEN IN STEM

Equity, diversity and inclusion (EDI) is gaining traction in the higher education and research community. This is creating momentum for the recruitment and advancement of women in STEM. Previously, EDI values were found primarily in centres serving students with learning disabilities or handicaps. However, nowadays they are finding their way to researchers.

Today, many research-granting agencies in Quebec and in the rest of Canada are incorporating EDI requirements into their programs to encourage the participation of designated groups (women, people with disabilities, visible minorities, and Indigenous people) (Social Sciences and Humanities Research Council of Canada & Canadian Institutes of Health Research., 2019). Applicants for research grants are required to explain certain aspects of interest – for example, how they address population diversity in their research projects and in the diffusion of results, what actions they advocate for the diversification of research teams and for the inclusion of their members, the equitable recruitment and promotion processes they envision. In some programs, the grant will not be awarded if a major concern for EDI is not demonstrated.

EDI is also making progress within administrative structures in colleges and universities. A key element of this progress is the Canada Research Chairs Program, which requires academic institutions to have an EDI action plan in place for awarding Chairs. The program is demanding and ambitious: it aims for transparency

in the processes, training selection committee members on unconscious bias, and establishing quotas for the representation of designated groups as chair holders.

The Dimensions: Equity, Diversity and Inclusion Canada pilot program is developing in parallel with these other initiatives. Modeled on the international Athena SWAN program, Dimensions will award prizes to colleges and universities that work to support equity, diversity and inclusion at their institutions. Again, structural change is the goal.

Why are granting agencies promoting EDI at their institutions? There are several reasons for the implemented changes. These include the contribution of more expert women and men with EDI concerns, the need for a broader notion of research excellence, and the employment equity that has been sought for some decades.

Reactions to the new EDI requirements range from expressions of approval for these initiatives to discomfort with the obligations and justifications they require. Some of them express a deep commitment to the principles of EDI, to a desire to learn about it and to an ambition to do more. However, other reactions express a fear of not being able to achieve what is required, a sense of not having the resources and knowledge, and simply being resigned to the obligation.

Despite the range of reactions and variable levels of inertia in the structures, the integration of EDI is a tool that forces the place of women in STEM to progress in a predominantly male environment. This community is more aware and recognizes the barriers and challenges faced by women, has a better understanding and consideration of the impact of unconscious bias, and is more sensitive to the potential benefits of diversity. As a result, an EDI-focused organization involves increased and improved actions to recruit more women into STEM, retain them in their jobs, and support them in their career paths. Thus, maintaining the momentum created by the implementation of EDI at universities is critical to continue to promote the recruitment and advancement of women in STEM.

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CHALLENGES AND ISSUES FOR NON-HETEROSEXUAL WOMEN WORKING IN STEM

According to 2015 data from Statistics Canada, 3.3 percent of Canadian women over 15 identify as non-heterosexual (1.1% lesbian, 2.2% bisexual, without further data on other categories) (Gilmour, 2019). What about in STEM? This statistic is difficult to obtain, as the few studies in this area incorporate data from the entire LGBTQ2S+ community[22]. In addition, the Canada Research Chairs do not include sexual and gender minorities within their designated diversity groups, which limits the available statistics[23].

Quebec was the first jurisdiction in North America to prohibit discrimination based on sexual orientation. This was achieved through the Charter of Human Rights and Freedoms, which came into effect in 1976. Likewise, it was the first to adopt an omnibus law recognizing the same rights for same-sex couples as for heterosexual partners in civil union marriages (in 1999). This legislation seems to support the presence of sexual minorities in the workplace; yet they remain invisible in STEM. In fact, while women still have to deal with the challenges created by the patriarchal history of STEM, those who identify as non-heterosexual also have to deal with the heteronormativity and culture of silence that dominate STEM.

Over the last few years, the level of acceptance of the LGBTQ2S+ community has grown. However, despite social change, STEM culture continues to imply that individual identities should be omitted from professional practice, as they might hinder the practice of science. This idea, combined with heteronormativity, creates a double standard, whereby being openly non-heterosexual often rhymes with being considered unprofessional. Hence, the resulting

invisibility of non-heterosexual women is a barrier to creating a diverse and inclusive workplace. Moreover, this contributes to a lack of role models, inertia in attitudes, and the stigma of coming out, which, rather than being an isolated event, becomes an ongoing exercise (Mattheis, De Arellano, & Yoder, 2020). In addition, this invisibility hinders the advancement of knowledge. Actually, several studies suggest that sexual, gender, ethnic, cultural and political diversity would contribute to the quality of research by providing fresh perspectives (Galinsky et al., 2015).

Therefore, the underrepresentation of non-heterosexual women in STEM is a challenge in the context of the desire for equity, diversity and inclusion. One may wonder about the impacts of such invisibility and the lack of role models or mentors on young girls' and women's desire to engage in STEM or on career advancement in the field, especially in countries still hostile towards the LGBTQ2S+ community. Moreover, studies have demonstrated that belonging to a minority group can disadvantage career progression in STEM in terms of satisfaction, success and productivity (Yoder & Mattheis, 2016). Indeed, how can you perform at your best and work comfortably in a team if your identity is left at the front door of laboratories?

Furthermore, as previously highlighted, women in STEM experience or perceive parenthood as one of the major hindrances in terms of their careers. This appears to be a particularly great challenge faced by non-heterosexual women. Once more, Quebec and Canada are pioneers in the accessibility of parenthood for the LGBTQ2S+ community. Since 2002, in the case of conception by assisted reproduction, same-gender parents have been able to register both of their names on the birth certificate (*Act instituting civil union and establishing new rules of filiation, Bill 84*). In 2004, a federal law on assisted reproduction was passed stipulating that clinics cannot refuse services to a person because of their sexual orientation or marital status. Nevertheless, aside from ethical considerations that may constitute a second barrier to acceptance (homosexuality and homoparenting), this may also involve challenges associated with assisted human reproduction, known to induce not only psychological stress, but also physical, financial, and time investments that may seem incompatible with the quest for STEM excellence.

In Canada, the acceptance rate of homosexuality has increased from 69 percent in 2002 to 85 percent in 2019 (Poushter & Kent, 2020). This increase is certainly good news, but it could also be misleading and encourage inertia as there are still many challenges to acceptance and inclusion of homosexuality in society and in some professional fields, STEM included. It is important for the scientific community to address these challenges for the benefit of future generations of scientists, as well as for the benefit of research. The lack of attention paid to the challenges of the LGBTQ2S+ community in STEM contributes to its invisibility. The challenge is to actively fight the pervasive heteronormative culture in STEM. Examples include implementing social and institutional policies, educating faculty, staff, and students about access to STEM through training on creating a safe space, and demystifying homosexuality as well as challenges faced by the entire LGBTQ2S+ community (see box). This would create an appropriate climate for openly non-heterosexual role models, inclusion of sexual and gender minorities, and the changes in mindset necessary for any positive change in a company.

How to create a safe space within your organization?

- Examine the internal climate of the organization (company, institution, lab) to assess whether it provides a safe space for the LGBTQ2S+ community.
- Provide training to anyone working in STEM on issues surrounding the LGBTQ2S+ community and tools to combat harassment and bullying.
- Facilitate access to specialized resources on LGBTQS2+ issues for all people working in STEM.
- Declare on the organization's website that creating a safe space for the LGBTQ2+ community is integral to its mission.
- Employ inclusive language in all formal and informal communications.
- Display stickers designating safe spaces.
- Conduct awareness activities during Pride Month.
- Host inclusive networking events.
- Implement workshops addressing authenticity in a professional setting.

Source: Girl's Best Friend Foundation and Advocates for Youth (2005).

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INDIGENOUS WOMEN AND STEM: AN IMPORTANT ALLIANCE

Indigenous women make unique contributions to the STEM field through their culture, thinking, worldview and history. Two contemporary female scientists are presented here as a source for future research concerning the contributions of Indigenous women in STEM.

PASSIONATE FEMALE RESEARCHERS

Innu-born astrophysicist Laurie Rousseau-Nepton developed an interest in nature while observing the Northern Lights with her family. She chose to pursue a career in astrophysics, which she considers the most philosophical of all STEM disciplines. "I'm trying to go back in time a little bit and understand the knowledge that our ancestors had of astronomy, and what you learn is always phenomenal!" (Radio-Canada Ohdio, 2021). Currently, she is studying about 40 galaxies close to ours, specifically, the areas of these galaxies where stars form (Janson-Marcheterre, 2020).

In medical research, biochemist Isabel Desgagné-Penix, who also has Innu origins, draws on Indigenous knowledge by studying medicinal plants and specialized plant metabolism (Groleau, 2020). Her expertise on medicinal plants, developed as a child in her family environment, inspires her innovative work. In particular, she grows cannabinoids in microalgae. The advantage of this process is that it requires fewer resources – light, space and nutrients – than growing cannabis traditionally (Agence QMI, 2019).

SPECIAL SITUATIONS FOR INDIGENOUS WOMEN

Like Rousseau-Nepton and Desgagné-Penix, more and more Indigenous or Indigenous-descended women are conducting research. They are raising red flags and contributing directly to various research projects. With their traditional and privileged knowledge related to subsistence activities, they have intimate knowledge of climate change and its impacts on their communities' health (Unpointcinq, 2018). This extreme attention to environmental health issues in Indigenous communities is explained through the direct impact that the health of the territory has on families (Assembly of First Nations, 2009).

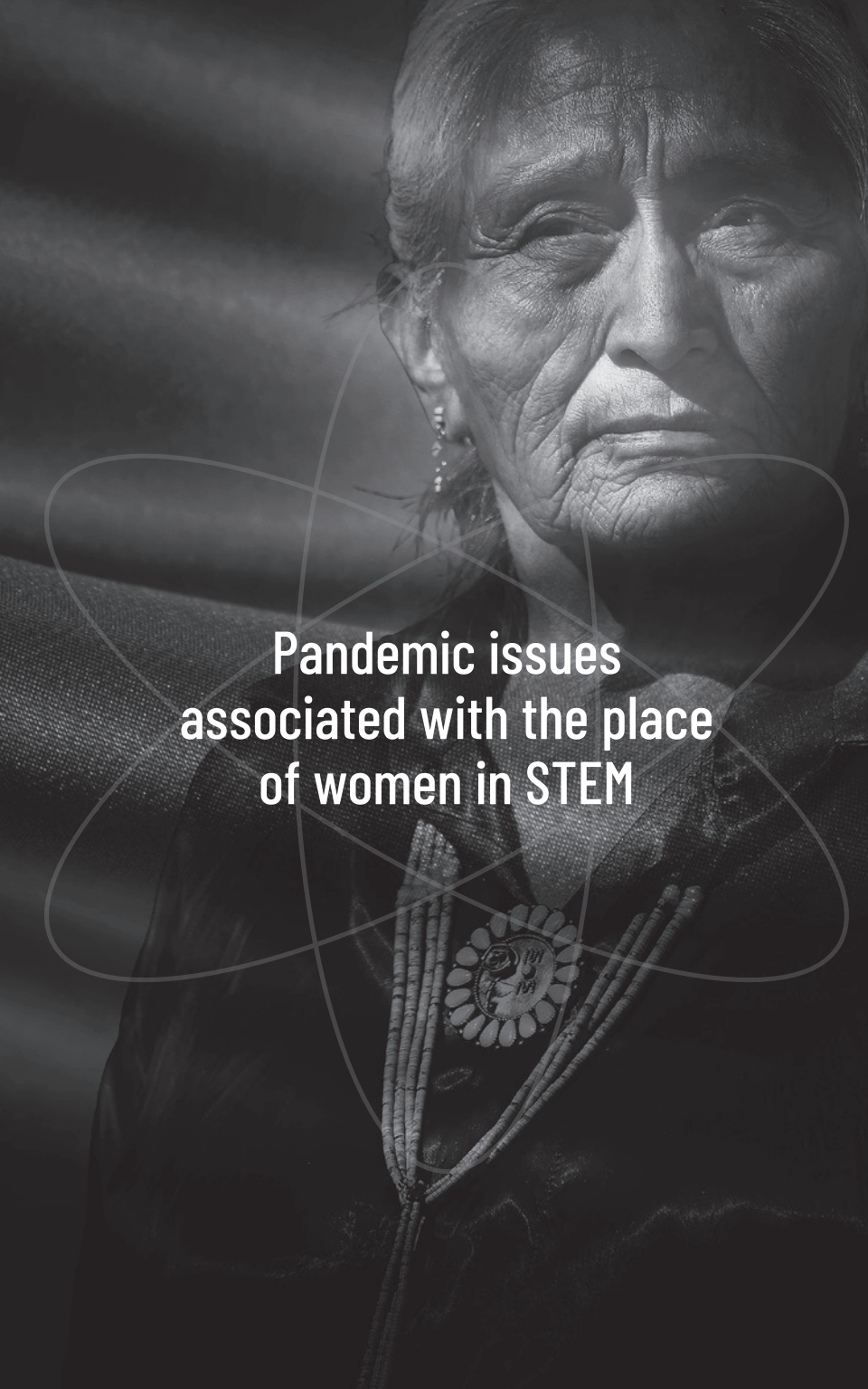
When Watt-Cloutier, in her book *The Right to be Cold* (2019), deplores the consequences of the dispersion of pollutants (pesticides, products used in industrial manufacturing, etc.) on Indigenous communities, she is concerned for the survival of her people. For example, mercury levels in seal and beluga livers consumed in Nunavik and Nunavut are a concern for the health of young children, pregnant women and women of childbearing age (Houde et al., 2020). Health advisories suggest limiting the consumption of these animals. This affects hunting and passing on traditional knowledge associated with it, quietly erasing fundamental aspects of Inuit culture.

From a social perspective, the effects of environmental health problems and the complications from the COVID-19 pandemic on the larger Indigenous family raise the issue of accessibility to safe health care. Indeed, the Quebec health-care system is currently grappling with issues of anti-racism for Indigenous patients. It is up to women and men in STEM, allying themselves with Indigenous women, to undertake the collective job of improving the situation of those who are often victims of racism when seeking and receiving health care (Lasalle, 2021).

While Indigenous women are important contributors to STEM research, they also have a relevant and unique cultural view of health that may help them address the challenges they face when it comes to environmental health, which is unfortunately a current topic.

THROUGH THE EYES OF OTHERS

All of this leads to a broader consideration of the importance of conducting feminist ethno-scientific research that examines the links between STEM and a people's culture (and vice versa) (Pallascio, Allaire, Lafortune, Mongeau, with the collaboration of Laquerre, 1998). We would thus move from scientific acculturation, "the process by which a social group, and ultimately each of its members, actively constructs its knowledge […] from situations experienced in a socio-cultural environment that is not its own" (p. 119), to scientific enculturation, which incorporates traditional perspectives such as worldviews into scientific research.



Pandemic issues associated with the place of women in STEM

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THE PANDEMIC AND DISPARITIES IN THE SOCIAL TREATMENT OF WOMEN AND MEN IN STEM

This *Manifesto* is intended to be positive and influential. It aims to sensitize the population and engage women and girls in the fields of STEM. It provides a unique opportunity to address women's issues in STEM to achieve sustainable change.

The fact that this *Manifesto* was written during the COVID-19 pandemic is remarkable. This unprecedented situation has clarified the importance of STEM in providing solutions to complex situations, while also highlighting some of the disparities in the social treatment of women and men in different STEM fields.

Here are some elements of this observation:

- It is recognized that women are the minority in science- and engineering-related professions. Similarly, although they are the vast majority in the health field, they are underrepresented in several medical specialties.
- Remote work and the closure of schools, kindergartens and daycare centres increased the difficulties experienced by families, particularly in terms of work-family balance. This will have a significant impact on women's careers, since they take on more family responsibilities than men and these duties have increased during the pandemic (Gagnon-Paré, 2020).

- The scientific community urgently needs people, regardless of their gender, to work on finding solutions and preventing further pandemics. We are in a race against time to overcome this human catastrophe and prevent others. Women in STEM are an essential resource in addressing this situation.
- We have seen that mathematics – particularly statistics – is essential to properly manage the pandemic and support decision-making. This has led to a demystification of mathematics and the use of numerical data among the population. We believe that this indispensable contribution of mathematics will attract more women into professions that rely on this discipline in particular.
- As the pandemic situation has shown, a high proportion of women are working to care for people in nursing homes and hospitals. The skills of women in STEM are needed, not only to participate in scientific and technological development, but also to create a more humane world focused on the well-being of people, a role traditionally valued by and for women.
- The presence of the COVID-19 pandemic has raised awareness of the fact that the work of women (often from diverse backgrounds) in the health field is very important, even essential. This necessity has too often been ignored and not sufficiently recognized.
- Artificial intelligence and digitization help analyze situations (political, economic, scientific, social and educational perspectives) and help sensitize people regarding the contributions of STEM to finding solutions to the current pandemic situation.
- We have come to the realization that women, many of them scientists, play an important role in the media in informing the public about the pandemic context. It is essential that the news media realize this and continue to call on women for their STEM expertise after the pandemic.

- The media would also benefit from choosing speakers with a variety of profiles (professional, ethnocultural, and so on) in order to offer more diverse role models and thus promote better representation of the different groups that constitute our society.
- Data on COVID-19 (the status of the pandemic, the impact on women's work, and more) collected in Quebec and the rest of Canada can be examined not only in our own country, but also from an international perspective. Greater North-South sharing of our respective expertise would enrich our experiences and knowledge in the fight against COVID-19.

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THE IMPACT ON THE CAREERS OF WOMEN IN STEM OF WORKING REMOTELY DURING COVID-19

The pandemic has created a new working environment by forcing many people to work at their jobs from home. The impact of the pandemic is likely to be greatest for those (women or men) who are in charge of family members – children, the elderly or disabled – in need of care.

A team of women working in the fields of medical physics and biomedical engineering conducted a survey in several regions of the world to evaluate the impact of the pandemic on the careers of women and men working from home. Workers in other STEM fields were also approached (Frize et al., 2021). The purpose of the survey was to determine the extent to which their situation had changed during the pandemic crisis and to assess whether the current policies of the organizations employing these professionals helped to minimize the negative impact of the pandemic on their careers.

This committee of women from the International Union for Physical and Engineering Sciences in Medicine (IUPESM) conducted the survey in June 2020[24]. The analysis took into account demographic and gender parameters for each variable studied to assess the impact of working from home on professional life. By the end of July 2020, the team had received about 1,000 responses: 339 men, 573 women, 9 people who identified as other genders, and 56 people who did not indicate their gender. Among them, 75 percent of men were married and 15 percent were single; 58 percent of women were married and 26 percent were single. More women

(70%) than men (59%) worked from home during the pandemic. However, a greater proportion of men (65%) than women (55%) had a home office.

The proportion of men who spent more than three hours a day caring for children or helping with school activities was 10 percent, while for women it was 17 percent. In terms of housework, 7 percent of men and 9 percent of women spent more than three hours per day on domestic tasks. The survey also found that 38 percent of men and 44 percent of women spent between one and three hours doing house chores.

It is interesting to note that men were involved in childcare and housework, but for shorter periods of time than women. However, this increase in male participation in home activities had already been observed for the past three decades (Houle, Turcotte, & Wendt, 2017).[25].

Generally speaking, since domestic responsibilities already have a greater impact on women's careers than on men's, it would not be surprising if remote work accentuated this gender imbalance. Management should therefore give serious thought to this situation and develop ways to minimize its negative impact on the professional status and career of each group of professionals working in medical physics, biomedical engineering and other STEM fields, with particular attention to the situation of women. It would also be pertinent to examine the impact of remote work on women and men in different regions of the world. This would be a good opportunity to explore differences between cultures.

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THE IMPACT OF THE PANDEMIC ON THE SITUATION OF FEMALE SCIENTISTS IN UNIVERSITIES[26]

An increasing number of women who are researchers, university professors in all fields, and scientists are being disadvantaged by the COVID-19 pandemic. This situation could have long-term repercussions on their collective position in universities. Solutions exist and vigilance is required.

Women still face more difficulties than their male colleagues in their career paths because of prejudice, stereotypes, work-family balance, extended absences due to motherhood and corporate policies that do not sufficiently take into account conditions unique to women (McKinsey Global Institute, 2020).

Over the past year, several works have been published on the differential impact of the pandemic on women and men, particularly because women are overrepresented in lower-paying or part-time positions, making their employment status more precarious than that of men. In addition, women are more affected by the implications of work-family balance because of the increased tasks related to family and children's education.

Female university professors, in particular, have been harshly affected by the pandemic in terms of the evolution of their careers. It is important to remember that the career paths of university professors depend on publishing scientific articles in specialized journals and their ability to raise funds to undertake research. Due to the reasons mentioned above, any decline in productivity in these areas puts women at a disadvantage in their careers.

However, the pandemic and subsequent lockdown have made it increasingly difficult for female academic scientists to reconcile their family and personal lives with their professional lives. As family tasks fall generally more to women than men, these researchers and scientists find it difficult to free up the time needed to write scientific articles, which are based on extensive literature reviews, field investigations, analyses of a large amount of data, continuous updating of their knowledge, intense periods of reflection and maintaining a network of contacts with leaders in their area.

Another barrier is the type of research that women do. According to Chasserio and Bollaert (2020), "female researchers mobilize qualitative research methods more frequently than their male colleagues. These methods require meeting people, being present on site to collect data. These protocols were stopped during the pandemic, postponed at best, but sometimes simply cancelled". The inability for many women to collect data also results in the inability to publish articles. This creates a lag relative to male researchers, who more often use quantitative methods, which require fewer face-to-face meetings, or rely on secondary data, which does not require an on-site presence.

This slowdown in the production of female scientific research will surely have an impact on the representation of women in the upper levels of our universities, although this unfortunate consequence of the pandemic cannot be measured at this time. Indeed, in general, promotion criteria already disadvantage women. Some may have left their profession, either because they could not reach their goals or because of professional or personal exhaustion. This impact could have repercussions on future generations, with fewer female role models to encourage future women to choose a scientific orientation.

In addition to this impact on the place of women in our universities, this loss or reduction of the female contribution to scientific research activity is liable to weaken society as a whole. For example, Vincent-Lamarre, Sugimoto, and Larivière (2020) argue that a strong scientific environment requires the participation of the entire population and that a crisis requires exploiting the intellect of all its members, both women and men. It is important to create an

infrastructure that allows the whole of society to participate in its renewal while recognizing systemic differences in the ability of each individual to do so.

A lack of vigilance could have a significant impact on the gains made by women over the past decades (Chasserio & Bollaert, 2020). This is not a desirable scenario, and it is necessary to act now to prevent the gains that have been made from being undermined or even wiped out. In this regard, some Canadian universities have already put in place solutions to better support professors by allowing them to delay their year of study and research (usually known as a "sabbatical") or their tenure application to compensate for the slowdown in their research caused by the pandemic.

The mechanisms for evaluating grant applications have also been revised to give candidates more time to improve their scientific curriculum vitae. It goes without saying that such adjustments can have a downside in terms of slowing down the process of obtaining a new status or promotion. However, as today's world has slowed down, it is better to ease the pressure on academics and provide them with the organizational support necessary to help them pursue their career ambitions at a more realistic pace. When applying for grants, it is already possible to indicate time off work due to parental or sick leave. It would be pertinent, in the future, for this practice to be extended, as was the case during the pandemic, to provide an opportunity to indicate the reasons for a career slowdown. This practice could also be applied to tenure and tenure applications.

To ensure that the learning of the past few months is not lost, subsidy programs should invite researchers to conduct investigations to measure the impact of the pandemic on women from all backgrounds, taking into account their age, status, sexual orientation and level of education. The gender equality gains made over the past decades are at risk. If we want to continue to move towards parity in all spheres of our society, it is imperative that we understand the current reality of women and the new barriers they have encountered since the beginning of the pandemic, in order to find ways to break down these barriers so that all women can reach their full potential, both for themselves and for society as a whole.

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HOW WILL GIRLS AND WOMEN IN STEM FARE AFTER THE COVID-19 PANDEMIC?

We are going through an unprecedented time in our modern history. The new coronavirus, that invisible enemy, has entered our lives at an alarming rate and invaded our human and social spaces. It is still too early to analyze the longer-term effects of this global pandemic, but philosophers and analysts agree that a phenomenon of this magnitude cannot help but substantially alter human paradigms and, consequently, socio-economic systems, on a global scale.

Since the beginning of this pandemic, governments have taken drastic measures to protect the population and stop the virus from spreading in order to save as many lives as possible. Only those services designated as essential, such as those related, in any way, to the health, social and community services sectors, have remained open and functional. Several sectors had to shut down for a period of time, including food services and retail businesses.

According to the Statistics Canada (2021) Canadian Census, the proportion of women in the workforce has changed little from 2006 to 2016, increasing slightly from 47.9 percent in 2006 to 48.2 percent in 2016. Quebec's health and well-being statistics reveal that, in 2011, women held 47.7 percent of jobs, across all occupational categories, with a strong majority in the health, social sciences, education and finance sectors (Ministry of Health and Social Services, 2018). They are also the majority in the arts and recreation fields, as well as in the sales and services sector, although the gender gap is smaller in these industries.

Societies have always underestimated the importance of so-called women's jobs, which are predominantly held by women due to historical factors, including the ideology of patriarchy, which has always considered women's work to be less important than that of men. Unfortunately, even today, consciously or not, people socialized by this traditional discriminatory system keep women in underpaid and undervalued job categories.

Will the pandemic make countries around the world realize that women-dominated jobs are more essential than ever, at least in health and community services? Salary increases have even been offered to those struggling to contain this scourge, including those at the bottom of the pay scale. It remains to be seen whether this treatment will continue after this devastating pandemic. In addition, over the past few decades, more women have chosen to invest in STEM careers. What will be their fate after the pandemic?

According to the 2016 Canadian Census (Statistics Canada, 2021), women are studying in different fields than men. They represent more than half of all graduates and 70 percent of graduates in education and health. Women graduates remain significantly fewer than men in mathematics, computer and information sciences (35%), personal, protective and transportation services (28%), and architecture, engineering and related services (20%). Despite improvements in their professional qualifications, prior to 2016, there were still few women in middle management (39.4%) and senior management (27.6%) positions.

Women still face many challenges in accessing jobs that were once reserved for men. For example, gender stereotypes that convey traditional societal expectations and beliefs about the abilities of women and men to hold leadership positions in STEM are still present. Several manifestations of these stereotypes can be noted: the perception of a higher level of stress associated with these jobs compared with those in so-called female fields and the inability of women to manage it, the absence of female role models, fewer training opportunities, and sexual and gender-based harassment. According to Dryburgh (1999), female engineers use a variety of strategies to

manage the tensions within and because of the dominant male culture. They work hard to create supportive relationships with their male colleagues.

Science and engineering careers have never been in greater demand than during the pandemic, with the importance of health research and the race to develop vaccines to stop the disease. The demands for creating equipment and tools to protect people working on the front lines have also increased. These are important jobs, which will be in even greater demand after the pandemic. According to Pleyers (2021) and Sfetcu (2020), the social and economic sectors will undergo a profound transformation as a result of this experience, which has disrupted several human systems. Certain human values and qualities will undoubtedly be sought in order to create a better world. Will the future be reserved for people who can generate new ideas and respond to emerging paradigms? Will the skills of women in STEM be more in demand to help create a more humane world focused on the well-being of people? Will women working in so-called women's sectors be respected and paid according to their fair value? Let's hope that women, particularly those working in STEM, will respond to the pandemic with their presence, ready to meet these new challenges.

In conclusion, the words of philosopher Alain Deneault, professor at the University of Moncton, were quoted in an April 2020 Radio-Canada article: "Beyond the health emergency, Alain Deneault believes that the coronavirus pandemic, as painful as it is, must be an opportunity for the planet to take a health break and rethink its production and consumption model" (Kouaou, 2020). In our opinion, this requires the full participation of women.


Make way for the pioneers

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CLAUDIE SOLAR: WOMEN'S KNOWLEDGE IN STEM

Does science have a gender? This question has been bothering me for years. I tried to find an answer once already, over 20 years ago (Solar, 1997). I explored it by noting that science includes "neither humanities nor arts". I went on to address both the teaching of science and the people who teach it, at the elementary, secondary and higher education levels, as well as outside the world of education, particularly in community groups, including women's groups. Finally, I shared my knowledge on "science as a living, working and learning environment" and discussed practices to encourage women to pursue science. The piece that came out of this reflective process was marked by testimonies of women who spoke about their relationship to science. I concluded this systemic view of women's exclusion from science by mentioning that the change towards their greater visibility was already in progress.

This question of gender and knowledge has challenged me throughout my journey in adult education and feminism. It was mathematics that led me to be concerned with the education of women[27], full-fledged adult beings that some people would prefer to keep in the myth of nature[28]. What concerns me about the relationship between gender and science is therefore the question of knowledge, more particularly the knowledge that women use and develop and that which involves them. Indeed, when I look back at the list of my writings, knowledge is of significant importance (Solar, 1990, 1992b, 1994b, 2001). Of course, I have relied on other authors – such as Jacky Beillerot (Beillerot, 1996, 1999; Beillerot, Bouillet, Blanchard-Laville, & Mosconi, 1989; Beillerot & Mosconi, 2006), Bernard Charlot and Jean-Guy Rochex (Bautier & Rochex, 2001; Charlot, Bautier, & Rochex, 1992; Rochex &

Crinon, 2011) and feminists Nicole Mosconi (Mosconi, 1989, 1994, 1996; Mosconi, Beillerot, & Blanchard-Laville, 2000), Michèle Jean (1984), Pierrette Bouchard (1995), Michelle Perrot (2006), Dorothy Smith (1978), Michèle Bolli (1985) and Roberta Mura (1991, 1998).

Today, I believe that the Equity Model I developed in 1992 (Solar, 1992a, 1992c, 1994b, 1998, 2017, 2019) enshrines the importance of knowledge, since it shapes our thinking. This assertion was taken up in a recent issue of *Recherches féministes* (2018), when Geneviève Pagé, Ève-Marie Lampron and I coordinated the dossier on feminist pedagogies. The articles that make up the dossier reveal a variety of approaches and concerns focused mainly on people or the group climate.

My doctoral dissertation focused on knowledge (Solar, 1988). The results of this research were used to develop courses for the Women's Advocates Development Program (Solar, 1986). There, I identified some key topics: "autonomy (personal and financial), work (domestic and paid), violence, politics and identity" (Solar, 1994a, p. 48). They are derived from the work of feminists who have addressed the omission of knowledge about women in the social fields.

There are more women studying in the humanities and social sciences than in STEM fields. Therefore, it is normal that we can find more knowledge about women's living conditions in these areas[29], while the data related to STEM is scarcer. I would say that it is only a matter of time, and that knowledge related to women in STEM will emerge when there is a greater interest in it and a greater participation of women in this field of study. They will then draw attention to their interests in STEM research and they will develop knowledge on which other researchers can build their approach, particularly about women in STEM. And a more inclusive knowledge of STEM will arise.

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JEANNE D'ARC GAUDET: SCIENTIFIC ADVANCES FOR WOMEN IN STEM

Over the course of the twentieth century, the evolution of human rights legislation paved the way for a greater democratization of education. Prior to 1973, few women had access to post-secondary education here or anywhere else in the world. That year, the United Nations Commission on the Status of Women prepared a draft convention on women's rights. In 1975, the participants at the first World Conference on Women voted that one-third of all goals to improve the situation of girls should be accomplished through education and training (Gaudet & Lapointe, 2004). As a result, women have had greater access to post-secondary institutions. That said, most continued to choose studies leading to traditionally female careers and professions. It took several years before they dared to move into STEM fields of study and work.

On December 6, 1989, a young man murdered fourteen young women, most of them STEM students, at the Montréal Polytechnique (Technological University) because they were women. This tragic event exposed the obstacles faced by young women who dream of studying and working in sectors from which they have long been virtually excluded.

In the years since, more girls have enrolled in STEM studies, particularly in engineering. However, according to Brière, Auclair, Deschênes, Fournier, Fournier, Lee-Gosselin, Goyer, Héon, and Laflamme (2018), there are some significant gaps remaining in the workplace in terms of salaries and representation of women in decision-making positions and in certain specializations.

During my doctoral studies in educational technology in the 1990s (Gaudet, 1996), I became interested in the issue of gender in education, particularly in instructional design models. Drawing on authors such as Baudoux (1994), Beauregard (1994), Belenky, Clinchy, Goldberger, and Tarule (1986), Berthelot and Coquatrix (1989), Bonenfant (1994), Carpentier and Turcotte (1988), Picot (1995) and Solar (1995), I conducted an analysis of a large number of learning program models developed in formerly male-dominated areas. I discovered that the majority of them catered more to the needs of male students than to those of female students. The situation was no different regarding teaching practices and learning strategies, among other things. This data prompted me to create and test an equity grid developed and validated with female and male trainers from large companies. The results were impressive.

In the following years, a colleague and I published a book entitled *Oui à l'équité : Réflexions et outils pédagogiques*, in which we addressed, among other things, training challenges for women in sectors leading to jobs in the new economy, sectors of employment predominantly occupied by men and requiring STEM skills (Gaudet & Lapointe, 2004). In addition, we were interested in the social factors that influence young people in the process of choosing an education or career, particularly young Francophone women who still hesitate to pursue STEM studies. We wanted to understand this phenomenon in depth. Thus, we continued researching on these issues (Gaudet, 2004, 2005; Gaudet & Lapointe, 2001, 2002b, 2002a; Lapointe, Gaudet, & Mujawamariya, 2013).

During these years, I was involved in the formation of the AFFESTIM network, which brings together female researchers and students interested in STEM issues. This collaboration has brought up learning and research opportunities for members interested in expanding knowledge in an under-explored field. For example, scientific activities have been carried out in collaboration with pioneers of the cluster, including Louise Lafortune, Claire Deschênes, Monique Frize and Donatille Mujawamariya. A few publications have been issued, including *Les grands enjeux des femmes pour un développement durable* (Gaudet & Lafortune, 2010).

Many feminists agree that post-secondary institutions have opened their doors wide to girls and women in recent decades and that there has been significant progress in increasing the number of female enrolments. However, we are still waiting for these institutions to take a critical look at the dominant learning culture, which caters more to the needs of men, especially in STEM fields. Women mention that they still feel like outsiders in these environments. This may explain why there are so few female engineers in Quebec universities (18%) and why only 14 percent of the members of the Ordre des ingénieurs du Québec are women (Brière et al., 2018).

Although much research has generated an impressive corpus of scientific knowledge on these issues, Brière and her colleagues (2018) mention that most of the studies they consulted document women's journeys without analyzing the organizational dimensions or listing the mechanisms that support these journeys. I agree, and I would add that, as long as we continue to study these issues without looking at the bigger picture, it will be difficult to gain an in-depth understanding of what is clearly a multi-faceted problem. In other words, it is necessary to use a sySTEMic approach to understand and address the challenges spread across the trajectory of girls and women in STEM. Certainly, there has been a shift in the mindset of social institutions in recent years. However, many girls and women in formerly male-dominated roles in STEM, for example, still struggle to break through the glass ceiling[30] because the systems that hire them do little to challenge the dominant culture rooted in organizational structures and favouring a two-tiered workplace.

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DONATILLE MUJAWAMARIYA: MY EXPERIENCE IN SCIENCE AND ENGINEERING FOR WOMEN IN STEM

> *To you who doubts the unique contributions of girls and women in STEM.*

I first encountered science and engineering the day I realized that I was one of the few privileged girls to have received a scientific education in high school in my native country. Indeed, in the late 1970s, I attended the very first science school for girls in Rwanda, founded in 1967 and directed by pioneer Marie-Jeanne Noppen. I pay tribute to her for her unique contribution to the scientific education of Rwandan girls (Mujawamariya, 2008), which also opened the door for them to the only university in the country. This training paved the way for me to pursue a bachelor's degree in chemistry and a master's degree in food science and technology. I completed my studies in 1993 with a doctorate in science didactics at *Université Laval* in Quebec.

The beginning of my academic career in science education at the University of Ottawa, in Ontario, awakened me to the underrepresentation of women in STEM in Canada. That was in 1994. My university served as a laboratory for an in-depth analysis of the situation of girls and women studying in non-traditional fields, as compared with the so-called humanities. The findings were alarming. There was a striking imbalance between girls' and women's enrolment in the humanities (almost 80%) and in STEM (20%) (Mujawamariya & Sethna, 2005; Sethna & Mujawamariya, 2003).

At the time of this study, almost two decades after the University of Ottawa adopted an Equity Policy in 1987, this equity mandate was still a mission impossible.

This unfortunate fact whetted my appetite and forged my determination to make my own contribution to the promotion of women in STEM. The year 2004 marked a major turning point in my research and teaching activities. Since then, the issue of women in STEM has been an important part of all my courses. I assumed a position that nourishes both my courses and my research (Lirette-Pitre & Mujawamariya, 2005; Mujawamariya, 2000, 2005; Mujawamariya & Guilbert, 2002). That same year I created the *Unité de recherche éducationnelle sur la culture scientifique* (URECS), which I still manage today and whose main mission is to bring science out of the laboratory and make it accessible to the general public. Science talks are held at URECS on a monthly basis. The university community and the general public are invited to meet and talk with experts or watch a STEM-related film and debate about it. Needless to say, I have invited as many women as possible to showcase their scientific contributions and technological innovations. The wide-ranging topics of these talks go from zero waste food (from A to Z) to the emotional intelligence of robots.

When it comes to research, 2004 coincided with the launch of two landmark studies: Society-Centred Educational Practices and the Retention of Women in Engineering and a Study of Factors Related to Girls' Postsecondary Program Choices. These studies, which converged on questions about women in STEM, lasted three years (2004-2007) (Lapointe et al., 2013; Mujawamariya, 2010; Mujawamariya, Gaudet, & Lapointe, 2012). The number of women in STEM remains small, which is why I came to the conclusion that issues of female interest are underexplored. So I embarked on a pilot study, from 2011 to 2016, with female and male students at all academic levels and their female and male professors in the Faculty of Engineering at the University of Ottawa. This study resulted in a bilingual (English and French) pan-Canadian project titled *Le génie au service des femmes : Rethinking the Spaces and Faces of Engineering*. Adopting a feminist perspective (Cronin & Roger, 1999), it seeks to revolutionize mindsets about what engineering is, the unique contributions of women to engineering (Castaño &

Webster, 2011; Mujawamariya & Mavriplis, 2017; Mujawamariya, Mavriplis, Fournier, & Adatia, 2019) and the best paths for women to take to ensure their rightful place in STEM, while advocating for an equitable and safe society (Mujawamariya, Fournier, Adatia, & Mavriplis, forthcoming). In short, the study aims to transform the hitherto rather masculine culture of engineering, rather than continuing to try to change women so that they conform to that culture (Mujawamariya, 2005).

My journey is ongoing. In my next projects, I will be visiting elementary schools and high schools to talk about the participation and promotion of girls and women in STEM with students, teachers, principals and, why not, parents – because it all starts at home. Parents, schools, colleges, universities and the community have a joint role to play in ensuring that the doors of STEM are opened to girls and women from here and elsewhere, and that society as a whole can reap the benefits of their scientific creations and technological innovations for the well-being and harmonious existence of all[31].

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LOUISE LAFORTUNE, MATHEMATICIAN AND FEMINIST: IMPACTS ON A CAREER PATH

Asserting myself as a feminist has not always been easy. My career has been twofold: 1) a commitment to the cause of women in STEM and, more broadly, a feminist social commitment; 2) a career as a professor-researcher in mathematics education, accompanying educational change (without forgetting my feminist orientation, but without proclaiming it). It has always been important for me to act in both the feminist and the educational community, in order to diminish the influence of prejudices and stereotypes towards women and all people.

ENGAGING IN THE FEMINIST STRUGGLE WITHOUT SAYING SO OPENLY

The creation of two associations has marked my commitment to helping women evolve in STEM. I have always believed in the need to bring people together who support the same cause. I was therefore at the origin of MOIFEM (International Movement for Women and Mathematics Education, 1986-2003) and AFFESTIM (Association de la francophonie à propos des femmes en sciences, technologies, ingénierie et mathématiques, 2003-present). I have always deemed it important to publish collective works to spread the word about the situation of women in mathematics and STEM. In my opinion, it is essential to raise awareness among female and male teachers, counselors, parents, and principals on how their actions, words, and attitudes have a great influence on girls' educational and career choices. I have also always felt it necessary to work in other areas to bring them on board to support the cause of women in STEM: contributing to the États généraux de

l'enseignement des mathématiques (1990), where the place of women would have been overshadowed without the intervention of those associated with MOIFEM; obtaining a doctorate on the affective dimension of mathematics so that women would feel validated by research results; publishing scientific articles or popular scientific work from a feminist perspective, without always specifying it, so as to reach a public wary of the term "feminism".

Taking each event of my life separately – as a mathematics student (1970-1973), as a mathematics teacher (at CEGEP, 1973-1997) and as a professor of mathematics didactics (at university, 1997-2011), it is not always easy to perceive the prejudices, the obstacles and their consequences on my career and life choices. However, by analyzing these experiences, it is possible to identify a form of discrimination. Parker, Pelletier and Croft (2019) refer to "micro-aggression" as unconscious, unintentional comments or gestures that may at first seem harmless. According to these authors, it is essential that anyone navigating school and work environments recognize their own actions that may subtly send inappropriate messages. These messages combine with others to instill low self-esteem and a lack of self-confidence, in some cases, even causing people to abandon their careers. This is not a trivial matter, and it means that there is still a lot of work to be done to achieve equity and equality between women and men in STEM and many other fields.

THRIVING DESPITE THE FEAR OF FAILURE IN ADVANCED MATHEMATICS

I learned to knit in second grade because I was finishing mathematics exercises too quickly. The teacher was trying to keep me busy. My interest in mathematics was already there, but the teacher lacked the resources to help me develop my potential. Here was already a situation that did nothing to help me see myself as a future mathematician. Later, being around male colleagues who would rather consult others than me for their opinions on mathematics problems also damaged my progress. This led me down a parallel

path of developing and showcasing my pedagogical abilities. Thus, I specialized in mentoring, helping struggling students get the tools they needed to take and succeed in CEGEP mathematics courses.

As far back as 1986, Mura, Cloutier and Kimball concluded that the degree of confidence in one's ability to succeed in mathematics is the determining factor in enrolling in science at the college level. Students who chose to go into this field show a higher level of confidence than others. Among these students, boys outnumber girls. However, Mura and her colleagues added that although girls showed less confidence in their ability to succeed in mathematics than boys, the observed gap could also be due to boys overestimating their abilities, as boys' academic performance was equivalent to that of girls. According to the OECD (2008), girls perform as well as boys in science and technology, but boys perceive themselves as more efficient. In 2015, the OECD again highlighted girls' lack of confidence in their own abilities in science and math. The importance of reversing or even eliminating biases against STEM so women and girls can positively perceive these disciplines is no longer in doubt. Such a change in attitude would allow them to readjust their self-perceptions about their ability to succeed and to venture into demanding fields, such as mathematics training.

Spencer, Steele and Quinn (1999, cited in Parker et al., 2019) highlight the negative impacts of stereotypes on many women's mathematics performance, which Steele and Aronson (1995, cited in Parker et al., 2019) refer to as "stereotype threat". This refers to the psychological effect associated with feeling judged based on a stereotype, which can diminish a person's ability to perform to their full potential (Walton & Spencer, 2009, cited in Parker et al., 2019). According to these authors, keeping silent about one's desire to study mathematics and not perceiving and projecting oneself as a mathematician is associated with the fear of being judged through the "lens of a stereotype". I am convinced that many women who had the potential to become mathematicians, who have always loved mathematics and would have liked to choose this field of study and, later, career, may have been influenced by the "stereotype threat" and thus not taken the leap.

PERFORMING AS A SECRETARY TO BE ACCEPTED IN A MALE WORLD

During my academic career in mathematics, I did what I thought I had to do to be accepted in this male world. For example, I offered my help as a secretary to my fellow university students (1970-1973) and to my CEGEP colleagues (1973-1977). It seems that acting as a secretary is still customary in 2019. In a study by Deschênes, Belletête, Langelier, Gauthier, Tanguay, and Brière (2019a), an engineering intern notes that she thought tasks would be shared equally in a work team, but unfortunately, she discovered it was quite the opposite. She explains that "There were guys who said: 'I have a tech background, I'll take the technical side; you're a girl, so you can be the secretary'" (p. 120). Even I was surprised to read this from interviews in 2016, as my own experience dates back to the 1970s. This finding could be discouraging, but it highlights the need to continue the struggle.

GETTING AN ACADEMIC POSITION BY OMITTING THE FEMINIST PART OF THE RESUME

Parker et al. (2019) highlight the influence of unconscious biases in hiring. But, in one of the academic positions I applied for, I consider the biases I experienced to be quite conscious in a large portion of the people (both men and women). Indeed, the women supported the words of a male colleague who did not want a feminist working on the affective dimension in their workplace. Others probably did not object because, under such conditions, it was difficult for some men to defend my candidacy. These same authors point out that "organizations tend to self-reproduce, that is, to hire similar people" (p. 30). Even in blind recruitment, anonymity is difficult to maintain. For example, feminist publications and interventions cannot be easily disguised in CVs – there are always some details pointing to the gender of the person. The only solution is to remove what may inconvenience some colleagues, or even hinder hiring. In 1996, I removed everything related to feminism from my CV and I was hired at a university where I had already applied for the same position. The first time, I had made no omissions in my resume.

It is important to keep in mind that the collective intelligence level increases when a group is composed of more women, as mentioned by Joecks, Kerstin and Vetter (2013, cited in Parker et al., 2019). These authors add that diversity generates innovation as well as more ideas and perspectives. Thus, it becomes imperative to address women's career retention, particularly as it relates to work-family balance (Parker et al., 2019). Beyond work-family balance, I also see this retention as important for all women, even those not looking after a family, who eventually get tired of struggling. In the early 2000s, I left the field of mathematics to pursue a career in a field of research that I felt was necessary, aimed at changes in education and pedagogy. I retired at the age of 60 to rediscover myself and affirm myself as I am. Today, women mathematicians have a better chance of living their passion in a world of openness and recognition for women.

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MONIQUE (AUBRY) FRIZE: ENGINEERING AND WOMEN: A LOOK AT THE LAST SIXTY YEARS

In the early 1960s, I didn't know any of the few female engineering graduates in Canada. There were not a lot of them, and none were in Ottawa[32]. So I had no role models and no encouragement to enrol in engineering at the university, except from Philippe Arvisais, an electrical engineering student at the University of Ottawa. Thus, it was with great excitement that I got into electrical engineering in 1963.

My first job as an engineer in a telephone company was very disappointing. So, in 1967, I pursued my dream of studying biomedical engineering at Imperial College in London with the help of an Athlone-Vanier Scholarship from the Engineering Institute of Canada. I was the second woman to receive this scholarship, following Hermine Borduas, a graduate of the Polytechnique Montreal, who received hers in 1964 (Frize, 2019).

Throughout this time, I found that, in general, our society perpetuated myths and stereotypes about women's abilities to study and work in engineering, science and mathematics. It became clear to me that, in order to change this, there was a need for more women in STEM, especially in decision-making positions: female university professors, women working in industry, in government, and in professional and scientific associations.

PROFESSIONAL COMMITMENT TO IMPROVE THE SITUATION

In 1989, I was appointed to the first NSERC[33] Chair for Women in Engineering (Northern Telecom/NSERC) with a mandate to encourage the participation of women in engineering-related professions at all levels, from childhood to retirement, across Canada. This Chair included a faculty position at the University of New Brunswick to conduct teaching and research in electrical and biomedical engineering.

I began my tenure as Chair for Women in Engineering one week after the École Polytechnique massacre in 1989, in which 14 women were murdered, the majority of whom were engineering students. This event created a major fissure in the sense of security for women engaged in traditionally male fields. For me, this was the beginning of a mission, and the driving factor that motivated me to fully invest myself for the next five years to have a strong and major impact on the growing participation of women in the profession. There was an urgent need to raise awareness and spread the message that women should not be afraid of engineering. During my time as Chair, I gave several seminars to engineering students. These were great opportunities to discuss the profession while informing them of the difficulties encountered by women, who are a minority in the field, and of the problematic, even inappropriate, and often unconscious behaviours of the male majority. These young women told me about their careers and their hopes.

I knew that one person alone could not accomplish the full mandate of the Chair across the country. Therefore, I decided to recruit female and male ambassadors to help me carry the project by giving talks about the situation and meeting with people who could run local programs. As a result, I gave over 400 talks and conducted over 400 media interviews between 1990 and 2000 in every province in Canada and in the Yukon.

It is impossible to recall, in these few lines, all the other actions taken to support the cause of women in engineering since 1989. In my opinion, what had the greatest impact was the creation of the Canadian Committee on Women in Engineering (CCWE) in 1990, which I chaired during the two years it existed. It produced

a very promising report (Canadian Committee on Women in Engineering, 1992), which identified the problems faced by women at all levels of education and professional practice and made 29 recommendations to enhance the participation of women in engineering. If all of these recommendations had been followed, we would have an equitable profession, representative of the Canadian population. These recommendations are still relevant today, and their implementation varies greatly depending on the institution. Take, for example, the recommendation for engineering faculties to hire an increasing number of female professors. Some universities have followed this recommendation, while others still have very few women faculty members. Some women have also left their departments or faculties because of difficult conditions or a negative environment, which made these places unsuitable for a career. Other recommendations were completely ignored. The first (1) and the last (29) were:

- CCWE recommends that the active role of women in engineering be portrayed so that parents and the public will encourage young women to pursue careers in engineering.
- CCWE recommends that associations of professional engineers make employers aware of the different perspectives and qualities women bring to engineering work.

EXAMPLES OF OBSTACLES FACED BY WOMEN

Dozens of young women at all levels told me about their difficulties. Many were struggling with serious issues that required case-by-case interventions. Several female engineers reported being laid off after having a child, for example. This is illegal, but the companies that do it find arguments to protect themselves by claiming a poor evaluation of the employee. Generally, women do not consider suing the company. They feel that the probability of winning the case or obtaining compensation is too low. They also fear being blacklisted when they look for a new job. Other students talk about sexual harassment by their supervisor. In all cases, it has been important for me to encourage them to file a complaint, to help them find a new job or a new research direction.

I myself was bullied at the University of New Brunswick while holding the Chair for Women in Engineering. On a few occasions, it was suggested that the reappointment of the Chair would be in jeopardy if I continued to accept invitations to speak publicly. Fortunately, the Chair was renewed. There were other incidents. I recount some of them in one of my publications (Frize, 2019).

Certainly, as I expected, there has been progress since the 1960s, especially considering the significant increase in the participation of women in undergraduate and graduate engineering programs and in teaching and administrative positions in Canadian universities. But we are still far from parity. What is essential, in addition to achieving an equal number of women and men in professional settings, is that environments adopt a culture that respects both female and male attributes. It is also important for women to have access to a career in engineering without being subjected to prejudice, sexism or harassment.

There are reasons to be optimistic, especially in the search for a new generation of young women and men who will contribute to scientific progress. The many organizations that are now concerned with this issue, including many non-profit organizations, such as AFFESTIM and CIWES-ICFIS[34], engineering faculties, student groups, government agencies and professional practice communities, have taken over and continue to press for major change.

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CLAIRE DESCHÊNES: FROM THE BEAUTY OF SCIENCE TO THE POWER OF ACTION

Fluid mechanics is at the heart of my professional practice in mechanical engineering. I have found beauty in the equations that simulate fluid flows. I have used simulations to improve the life of hydraulic turbines. I shared this passion with my students. However, I have always missed the presence of women in my academic and professional environment, despite having a great relationship with my colleagues. Getting more women interested in the STEM field became my second mission. I am not the only scientist to have taken this path: many female colleagues have participated in the women-in-STEM movement since the 1970s in Canada. In them, I found both the female presence I was missing and an essential support network.

As the NSERC Chair for Women in Science and Engineering from 1997 to 2005, I discovered the great questions posed by internationally renowned researchers on the issue of women in STEM[35]: What is the contribution of women to STEM (Marianne Gosztonyi Ainley)? Why are women leaving STEM (Sandra Hanson)? What are distinctive female perspectives on nature (Sandra Harding)? I have also incorporated the results of Quebec feminist research, such as that of Roberta Mura, Louise Lafortune, Jeanne d'Arc Gaudet, Claudie Solar, Karin Messing and Francine Descarries, into my knowledge.

The Chair team compiled the first university participation statistics based on gender in Quebec, covering the years from 1970 to 2000 (Foisy, Gingras, Sévigny, & Séguin, 2000). At the end of my time as Chair, in 2005, the participation rate of women newly enrolled

in Bachelor of Science and Engineering programs in Quebec was 32 percent (Sévigny & Deschênes, 2007). This was the only area of university study where the participation rate of women was in the minority. This is still the case. Why has it been so slow to change? Refining the statistical analysis brought two important points to light. First, women in STEM are concentrated in certain fields close to the life sciences and are neglecting others, related to physics and computer science. Second, women are more evenly distributed across university programs than men (but the result is that only 15% of women at the bachelor's level in Quebec are enrolled in a science and engineering program, compared with 41% of men[36]). In an ideal world of gender equality, we could aim for a better statistical balance of women and men across all sectors: more female engineers in STEM, but also more male nurses and preschool teachers, depending on the workforce needs of society as a whole. This would ensure that a gap in the so-called women's professions is not created in favour of STEM. But we are not there yet, as gender biases persist and professions are not perceived as being of equal value. This creates mechanisms for the exclusion of women from traditionally male professions.

At the time of the Chair for Women in Science and Engineering, we identified several possible mechanisms accounting for the exclusion of women from traditionally male STEM professions. These mechanisms are social (societal prejudices), educational (pedagogical practices, lack of knowledge of these programs of study, anxiety about mathematics, difficulty in projecting oneself into the role of a female or male STEM professional) and organizational (subtle discrimination in companies). We surveyed the practices of many academic and professional settings; we analyzed the barriers and facilitators to women's advancement; we flushed out the biases and harmful social representations. This knowledge helped to better target action plans to support women's presence, advancement and retention in their STEM-related professional practice. For example, the creation of engineering programs more closely aligned with the health and environmental fields (water engineering, biomechanical engineering and environmental engineering) has partially mitigated the underrepresentation of women in STEM.

Some women have now broken the glass ceiling in STEM by reaching the highest positions of responsibility and leadership. Is this enough? What power do they have to reshape reality for women in STEM who follow in their footsteps? Do our allies, science policy managers and politicians, have the authority and budgets in hand to make a difference? One positive example is federal Minister Kirsty Duncan[37], who has made a change in the assignment of Canada Research Chairs to encourage greater diversity. Despite these advances, issues related to work-family balance, sexism in the workplace, hiring and career advancement persist for women in STEM (Deschênes, Belletête, Langelier, Gauthier, Tanguay, & Brière, 2019a, 2019b).

It is my belief that the issues have not yet penetrated society's consciousness sufficiently. A look at women in STEM as a group shows that, although their presence has increased recently, their contribution remains almost intangible, because their influence as a group is not sufficiently convincing to change the situation, historically speaking. This idea of influence is not new. At a preparatory meeting for the creation of the International Network of Women in Science and Engineering (INWES) in Merrickville in 2002[38], we identified the need to create a clear, strong, and effective voice for women on science issues in general, in addition to issues related to women in STEM. This desire has not yet been fully realized. There was an echo of this idea at the Gender Summit in Montreal (Holmes & Natural Sciences and Engineering Research Council of Canada, 2018), which aimed at increasing the social relevance and impact of research and innovation as its third path for action[39]. In addition, new concerns have come to the forefront in recent years, such as the quest for an equitable presence of racialized, Indigenous, and ethnicized women in STEM. Equity, diversity and inclusion policies have been put in place in various settings, which is positive, but they have yet to bring about all the desired changes.

I am convinced that many women would enrol in certain STEM fields if they could find rewarding jobs in them, as I did. There is beauty and power in STEM. Let's use it to address health, environment and global warming issues in a sustainable way. For me, the only way forward is for women and men, all of us together, including minority groups, to achieve a balance between the well-being of humanity and the preservation of nature. It is urgent!

Conclusion

This *Manifesto* proposes 50 texts addressed to the entire population. It brings together the reflections of female and male authors and school, university and the private sector groups working on the issues of women in STEM (science, technology, engineering and mathematics) in the Canadian French-speaking world. Things have changed a lot in the last 30 years. Older issues about women in STEM are revisited in this *Manifesto* in light of recent developments. We are no longer trying to prove that women have a place in STEM. And we are no longer questioning whether women have an essential role in STEM: we claim it. However, we are still trying to uncover and affirm their contributions to STEM, which is important for promoting STEM careers to young women and providing role models of women working in the field.

Mentoring is still seen as a critical tool to avoid mid-course STEM defections and to facilitate early career insertion. Several important issues remain, such as work-family balance and motherhood without penalty for women – in school or in professional practice. More modern issues such as intersectionality, EDI (equity, diversity and inclusion) and the impact of the COVID-19 pandemic on women in STEM are explored. Of note are the pieces at the intersection of STEM and the fields of health (such as reproduction), the arts (with film), education and even philosophy. Receiving them surprised, delighted and intrigued us. They open up a great space for future research. We also present, out of concern for doubly minoritized women, such as Aboriginal women and non-heterosexual women, another promising field in which the tools of EDI will be used to promote the place of all women in STEM. We wonder about issues that the COVID-19 pandemic has shed light on, such as its impact on career advancement for women in STEM, which is hindered because they still shoulder a greater share of family responsibilities on average. As we have often said, this *Manifesto* is intended to be positive and impactful, even though there is still a long way to go towards equity and parity. That is why we are presenting many initiatives and solutions. We want to go further, however, by proposing one recommendation per section of the *Manifesto*. We hope that each one will be taken up by a group of

people interested in the situation of women in STEM, that action plans will be designed, and that they will be implemented and evaluated. These recommendations are followed by suggestions of how to use the texts in this *Manifesto about Women in STEM: 50 Positive and Impactful Texts* in pedagogical settings.

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RECOMMENDATIONS FOR A SOCIETY THAT FOCUSES ON EQUITY, DIVERSITY AND INCLUSION OF WOMEN IN STEM FROM AN INTERSECTIONAL PERSPECTIVE

RECOMMENDATION 1: STATUS OF THE QUESTION OF WOMEN IN STEM

Develop a comprehensive and evolving depiction of the situation of women in STEM in the Canadian French-speaking world. Draw on their history, records of their place in these fields, various statistics and the numerous research studies on their situation in STEM to identify the major stages of this history.

RECOMMENDATION 2: WORK-FAMILY BALANCE FOR WOMEN IN STEM

Draft a brief that would serve as a basis for discussion with government and academic organizations as well as private companies so that women scientists can contribute to the development of society in their own right and are no longer penalized for their family-life choices. Propose and implement large-scale strategies for a work-family balance that is truly supportive of women working in STEM so that they can plan a family life that is combined with a possible career in the field without suffering the consequences of their choices.

RECOMMENDATION 3:
ABOUT WOMEN IN STEM

Recognize that women in all STEM fields play an important role in helping society progress. Provide ways to develop approaches that demonstrate the specific contributions of women in various STEM fields from an interdisciplinary and transdisciplinary perspective.

RECOMMENDATION 4:
INSPIRING APPROACHES BY AND FOR WOMEN IN STEM

Compile a comprehensive review of all programs implemented, research conducted, and writings produced by and for women in STEM over the past 40 years within the Canadian French-speaking world, both in terms of organizational and educational strategies and the promotion of STEM careers. Make this information readily available to encourage the creation of innovative activities that go beyond those already designed, implemented and evaluated.

RECOMMENDATION 5:
INTERSECTIONAL ISSUES CONCERNING WOMEN IN STEM

Bring together women from diverse backgrounds to find innovative ways to address the situation of women in STEM and the disparities in this diversified group: Aboriginal women, non-heterosexual women, women from various STEM fields, women scientists who worked in the COVID-19 pandemic, STEM pioneers… The overall state of all women in STEM focusing on intersectionality and EDI (equity, diversity and inclusion) would allow the Canadian French-speaking world to position itself as a force working to ensure that women in STEM can take their rightful place.

RECOMMENDATION 6:
PANDEMIC ISSUES ASSOCIATED WITH THE PLACE OF WOMEN IN STEM

Establish a post-pandemic focus group to examine the role of women in STEM during this extreme global situation and to ensure that their contribution is recognized and continues to be recognized after this crisis.

RECOMMENDATION 7:
MAKE WAY FOR THE PIONIEERS

Develop a mentoring program involving women pioneers who have been working in STEM or conducting research about women in STEM for a long time. This program would include initial training and continuing education for new mentors, implementation strategies, and a broad dissemination of resources and impact in matters of work-life balance, retention of women working in STEM, and incentive to engage in these areas.

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PROPOSALS FOR A REFLECTIVE AND INTERACTIVE PEDAGOGICAL USE OF THE *MANIFESTO ABOUT WOMEN IN STEM: 50 POSITIVE AND IMPACTFUL TEXTS*

The *Manifesto about Women in STEM: 50 Positive and Impactful Texts* is intended as a means of raising awareness of the situation of many women in STEM from a perspective of intersectionality, equity, diversity and inclusion. We want this *Manifesto* to be read, but also to be used for reflection and interaction between members of different groups: elementary, high school and CEGEP (pre-university college) teaching teams, university departments, but also various student groups, for example in teacher training or in techno-scientific professional training courses. We therefore propose strategies for reflective and interactive pedagogical use of the *Manifesto* from an intersectional perspective.

The following is a set of questions that could be used to formulate a reading goal or purpose before beginning to read the *Manifesto* texts or to serve as a basis for a post-reading exchange or discussion. The reading purpose corresponds to an objective, a goal that each person who reads relies on, more or less consciously, and that guides their reading. The reading purpose is often accompanied by the formulation of predictions about the text based on the title. It is advisable to return to the reading purpose at the end of the activity; it may even be the first topic of a discussion.

FORMULATING A READING PURPOSE

- For what reason are you interested in reading this *Manifesto*?
- From the title of the text, what are your predictions about the topic or content covered?
- What do you already know about the topic or content of the text?
- What information do you think you have access to?
- What else would you like to know?
- What are you looking to discover in the text you are about to read?
- Name an issue you think would benefit from being addressed in the text.
- Are you looking for a solution or solutions to a problem you already know about? What is that problem?

FEEDBACK ON READING PURPOSES

- Think back to your predictions. In what ways were they confirmed or denied?
- Think back to your reading purpose. Did you achieve your goal? Why?

REFLECTIONS AFTER READING

- What do you take away from this text or these texts?
- What did you learn from reading this work that was new to you, that you did not know?
- How does this reading change your awareness?
- What might you change in your attitudes, in your words, in your opinions as a result of reading this *Manifesto*?
- If you had one idea to offer for discussion, what would it be and why?

- What do you think your colleagues or group members think of this type of text?
- Who should be offered the *Manifesto* to read? For what purpose?
- If you had a text to write for the purpose of inserting it into the *Manifesto*, what would it be about? Why?

QUESTIONS ABOUT ACTIONS

- What strategies or actions would help improve the situation for women in STEM?
- What policies could be adopted to improve the status of women in STEM?
- What are the benefits of fostering a better situation for women in STEM?
- How can the entire population – parents, school staff, scientists, women, and men – be educated about the status of women in STEM?
- If you had to act, how would you promote better STEM orientation for women? better retention? better work-family balance?

TO GUIDE READING AND PROMPT REFLECTION-INTERACTION, YOU COULD PROPOSE:

Before reading

- A group or team discussion of predictions of the text's content based on the title.
- A written formulation of one's reading purpose.
- A voluntary group exchange about reading intentions.

While reading

- Individual note taking without losing sight of the reading purpose.

After reading

- ➜ Collective feedback on predictions.
- ➜ A moment of personal reflection before the discussion to revisit the reading purpose.
- ➜ A team discussion of reading purposes, followed by large-group feedback.
- ➜ A synthesis of main ideas following the group discussion.
- ➜ Pooling questions that remain after the large group discussion.
- ➜ Suggesting other texts from the *Manifesto* to read to enrich the exchange or elicit other reflections-interactions.
- ➜ A search on specific topics associated with the situation of women in STEM to further explore the themes addressed in the *Manifesto.*

Please feel free to circulate your copy of the *Manifesto*, discuss it with your colleagues, or use it in the classroom!

I DREAM OF THE DAY WHEN

There will be equity and equality between women and men in STEM

Women from all backgrounds (sexual orientation, culture, ethnicity disability…) will be equals in the field of STEM

Stereotypes and prejudices about women in STEM will no longer have a hold or impact on their life situation

Women in STEM will be able to work with the same perceived potential as men

Women in STEM will be able to publish on the same level as men on topics that concern them

Women in STEM will be comfortable in their living and work environments without fear of harassment or violence

Women in STEM will be able to balance work and family without fear of professional loss

Women in STEM will have acted together for a truly sustainable and respectful development on Earth

There will then be no need to publish a positive and impactful Manifesto about Women in STEM*!*

Epilogue

It is a privilege to write this note after having read all the testimonies presented in this book, which, I am convinced, will advance the place of women in science in Quebec and elsewhere. Many of the statistics given in this book raise serious issues that should be addressed. Despite many collective efforts, including the establishment of networks such as AFFESTIM, the presence of girls and women in science has made little progress over the past 50 years.

Although a majority at the college and undergraduate level, women still remain a minority in engineering and many STEM-related fields, which Pierre Doray describes as a "massive segregation" (Conseil supérieur de l'éducation, 2019). The problem is not limited to Quebec. Thus, several authors of this *Manifesto* refer to the newsletter published by UNESCO (2019) on the underrepresentation of women in science around the world.

Several texts also point to difficulties related to women's retention and progression in STEM-related careers. Others suggest that the pandemic that still disrupts us today affected women and men differently, as the health crisis accentuated pre-existing barriers to scientific productivity and opportunities for women to engage or advance in science.

At the same time, the *Manifesto* offers inspiring solutions. There is a lot of talk about mentoring, which could take place at many levels of the educational system, including, perhaps most importantly, in disadvantaged areas. Science exhibits, laboratory tours, and lectures by women who have pursued science studies and careers are all initiatives that have been organized for many years. The creation of international days dedicated to women in science under the aegis of the UN or the one dedicated to Ada Lovelace, considered the creator of the first algorithms, allow a few days a year to draw attention to the growing involvement of women in STEM.

In fact, the *Manifesto* is rich in suggestions that should help bring women to science and keep women in science. The advice is varied, touching on contraception, motherhood and existing networks. It

also describes the progress made by granting agencies, especially in relation to the Canada Research Chairs and the new Dimensions program, which seeks to promote equity, diversity and inclusion (EDI). Engineers Canada's "30 by 30" goal (30% women by 2030) is now being taken up by most of Quebec's engineering schools, and some have already achieved it in terms of admissions.

Time and again, the theme of education comes up as a solution to the barriers to the involvement of girls and women in science. Whether it is initiatives that reduce anxiety about learning mathematics or science in elementary school, awareness and training about the existence and control of unconscious bias in mentoring programs, or assessment, in both the educational system and the workplace, education remains a key element in promoting EDI principles.

In short, although the statistical depiction of the presence of women and girls in science may appear a bit bleak, the quality and quantity of individual and collective initiatives presented in this *Manifesto* allow us to envision better prospects in the short and medium term. The inspiring testimonies of pioneers such as Claire Deschênes and Louise Lafortune remind us that it is possible to carry out immense projects in the fields of science, engineering and mathematics. Their involvement deserves to be highlighted and valued. It is therefore with great hope that I write this epilogue to a book that will be published 50 years after I myself took my first steps in a research laboratory. The message I would like to share with you, which emerges from the entire *Manifesto*, is that the passion for research and science has no age, no race, no gender; it is simply universal.

Maryse Lassonde

President of the *Conseil supérieur de l'éducation du Québec*

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Endnotes

1. Adaptation of children's letters to mathematics (see the book *Chères mathématiques* (Lafortune & Massé, in collaboration with Lafortune, 2002), published by Presses de l'Université du Québec, who generously allowed us to use excerpts from the book.
2. Adapted from a text published in 2014 on the "F-STIM.org" site that was deactivated at the end of 2021.
3. Some resources: Government of Canada, *Les jeunes Canadiens* (2021), l'*Ordre des conseillers et conseillères d'orientation du Québec* (2021) and the *Réseau des carrefours jeunesse-emploi du Québec* (2021).
4. This is an adaptation of one of the recommendations from Gender Summit 11 (Holmes & Natural Sciences and Engineering Research Council of Canada, 2018), an event held in Montreal in November 2017 that brought together more than 650 people interested in diversity issues, particularly in STEM fields.
5. The Canadian women in STEM archive is a partnership of the Canadian Institute from women in engineering and science (CIWES-ICFIS), the University of Ottawa and Library and Archives Canada (LAC).
6. Table 11.1, p. 232, "Démarche dynamique et transversale pour la progression des femmes dans les organisations," in Brière (2019).
7. For instance, the Esp'Opk association – Hope for Polycystic Ovarian Syndrome (2019).
8. This text is adapted from Lafortune and Massé, in collaboration with Lafortune (2002).
9. Twelve non-traditional occupations were examined in the study led by Brière (2019), which is the focus of the research of Deschênes et al. (2019) presented in this text. Engineering was ranked sixth in terms of the "women-friendly occupation" criterion.
10. This model was developed by Amina Yagoubi, PhD in Sociology.
11. See data from the American Physical Society and the Integrated Postsecondary Education Data System (2021).
12. To learn more, follow International Queue Day on twitter: #IDG. A year can be added to the keyword, for example #IDG2020.
13. Text adapted from Lafortune and Massé, in collaboration with Lafortune (2002).

14. Samia is a fictitious name. That said, this story is true, and it was told to us by the Montreal Movement Girls & Code (MMFC) (Concertation Montreal, 2021c). The MMFC has been around since 2017, and its main mission is to encourage girls and young women to develop an interest in technology and pursue a career in it. One of its objectives is to bring together a group of Montreal companies, non-profits and educational institutions that are committed to parity and diversity in their environments and their various technological activities. This movement is led by Concertation Montréal (2021a).
15. The *Les Scientifines* organization (n.d.) has been working for over 30 years to promote STEM among young people aged 8 to 17 from disadvantaged backgrounds to enable them to develop various cross-cutting skills, thus countering school dropout and poverty among women. Most of the participants live in the southwestern part of Montreal, mainly in the neighbourhoods of Saint-Henri and Little Burgundy, which are recognized as socio-economically disadvantaged.
16 Survey conducted by *Les Scientifines* to study the long-term impact of STEM awareness activities offered over the past 30 years. The survey targeted young participants to better understand their perception of their time at *Les Scientifines*.
17. Among these, the *Parité sciences* project (2021) is one of the most recent. This large-scale project has been offering training on the relevance and use of inclusive and equitable strategies to CEGEP and high school teachers in mathematics, physics and computer science throughout Quebec since January 2021. The goal of this project, inspired by the American Step-Up project (American Physical Society, 2020), is to increase university enrolment in STEM fields with a significant focus on women. Also of interest are the programs of Poly-FI (2018), an organization that has taken over the activities of the Marianne-Mareschal Chair and those of the five NSERC Chairs for Women in Science and Engineering (these chairs can be accessed through the Chaire pour les femmes en sciences et en génie au Québec (2021) website)
18. Several of these were proposed by *Parité sciences* (2021), Poly-FI, *Femmes ingénieures* (2018), *Les Ingénieuses de l'ETS* (n.d.) or by the *Chercheurs de demain* project (Pinsonnault, 2019).
19. In the early 1970s, Matthew Lipman and Ann Margaret Sharp of the Institute for the Advancement of Philosophy for Children at Montclair University in New Jersey developed a program called Philosophy for Children for preschool, elementary and secondary school children. Inspired by this program, many philosophical approaches have been developed over the past thirty years in several countries. See, in

particular, the adaptation in mathematics by a team from the *Centre interdisciplinaire de recherche sur l'apprentissage et le développement en éducation (CIRADE)* affiliated with the *Université du Québec à Montréal* (Daniel et al. 1996b, 1996c, 1996a).

20. The methodology used in these approaches proposes five steps: 1) reading an episode from a novel or a story by the participants; 2) collecting questions of a philosophical nature raised by these people; 3) individual or team reflection before the group discussion; 4) philosophical discussion in a community of research; and 5) individual reflection after the philosophical discussion.
21. This methodology was used by an AFFESTIM team as part of a training project funded by the NSERC Promoscience program from 2016 to 2019 to renew STEM teaching practices related to sociopedagogical equity. The results of a research study (Pallarès et al., 2021) show the need for such philosophical approaches to ensure the gradual implementation of a reflective culture in pre-service and in-service training in mathematics education.
22. Lesbian, gay, bisexual, transgender, queer (or questioning) and two-spirited people. LGBTQ2S+ is used as an umbrella term.
23. See Canada Research Chairs (2021), *Equity, Diversity and Inclusion Requirements and Practices*.
24. Permission to distribute the survey was obtained from the Carleton University Ethics Committee and IUPESM. The survey was designed on the Survey Monkey platform. Analysis was performed using the IBM SPSS statistical analysis platform.
25. According to Houle et al. (2017), the proportion of mothers who performed housework in Canada remained unchanged between 1986 and 2015 (93%). Among fathers, however, this participation rate increased by 25 percent, from 51 percent in 1986 to 76 percent in 2015. In 1986, mothers spent 203 minutes per day on housework; fathers, 120 minutes. In 2015, these times were 181 minutes and 145 minutes, respectively.
26. This text is adapted from Champoux-Paillé and Croteau (2020). It is published with permission from the online publication *La Conversation*.
27. The author is a mathematician by training.
28. See the work of Francis Dupuis-Déry (2018).
29. For example, in history, sociology, psychology, education and social work, to name a few.

30. The term "glass ceiling" refers to "a particular form of inequality between women and men in organizations, which concerns access to positions of power" (Laufer & Muller, 2011, p. 132).
31. To follow Donatille Mujawamariya's path, visit URECS (n.d.), Engineering for Women: Rethinking the Faces and Spaces of Engineering (n.d.), and Equity Project/Projet d'équité: uOttawa (2021) on Twitter.
32. These include Elsie Gregory MacGill and Dormer Ellis, 1927 and 1947 graduates, respectively, both from the University of Toronto, and Helen J. Baxter, 1947 graduate in civil engineering from the University of New Brunswick.
33. Natural Sciences and Engineering Research Council of Canada (NSERC), a Canadian federal agency that supports research and training in these fields.
34. Canadian Institute for Women in Engineering and Sciences (CIWES) – *Institut canadien pour les femmes en ingénierie et en sciences* (ICFIS), directed by Monique Frize.
35. References to the writings of the individuals cited can be found in the digitized AFFESTIM Mediagraphy and Bibliography (2021).
36. Data provided by the NSERC Chair for Women in Science and Engineering in Quebec, for the 2019–2020 year.
37. Kirsty Duncan was Canada's Minister of Science from 2015 to 2019 and Minister of Sport from 2018 to 2019.
38. Monique Frize, Moyra McDill and Claire Deschênes invited 18 women specialists from eight different countries to Merrickville to lay the foundation for the organization
39. This voice of women working in STEM is just beginning to be heard. The COVID-19 pandemic, for example, has allowed several women to speak out publicly. Among them are Canada's Chief Scientist, Mona Nemmer, and Canada's Chief Medical Officer, Theresa Tam.