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Women & post-doctorates:

life after graduation

Prepared for the Canadian Commission for UNESCO
by Jocelyn Baker and Liette Vasseur
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About the authors

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Background

The reasons for the underrepresentation of women in STEM is not the focus of this paper as there is a large and growing body of research dedicated to this field of research (Lincoln et al., 2012; Sugimoto et al., 2013; Aiston & Fo, 2020). The need for this reflection paper originated from round table discussions organized by the Canadian Commission for UNESCO with L'Oréal For Women in Science Award (2019) laureates and other organizations active in equity, diversity, and inclusion (EDI). Many of the L'Oréal laureates shared their perception that once they had obtained a PhD diploma, the only possible career path was academia. The aim was to examine the career trajectory of women after they obtain a PhD in a STEM field, and to explore opportunities and avenues of solutions to better support their career paths. Here, we focus only on those who have graduated from a PhD. While this paper is mainly targeted at women in STEM, many of the reflections can be applied to other groups (races, gender orientations, etc.) and disciplines (e.g., social sciences and humanities).

Introduction

Labour markets predict that the next generation workforce will change careers more often, work remotely as the norm, and have more jobs in technology and innovation (replacing traditional labour sectors) (St. Clair et al., 2017). The development and investment in human capital is seen as a necessary component of shifting labour markets (Statistics Canada, 2016; Jonker, 2016; Waaijer, 2016). As careers are becoming increasingly knowledge intensive, advanced university credentials are becoming an essential part of rapidly changing and competitive economies (Waaijer, 2016; NSERC, 2017).

Over 7,000 PhDs graduate in Canada each year, bringing immense value to this country. They distinguish themselves as experts in their fields of study, developing highly transferrable analytical and intradisciplinary research skills. The PhD degree is a validation of academic excellence and recognition of advanced knowledge holders that are well equipped to impact society. From an industry perspective, PhDs drive research, innovation, and technology and are advanced in knowledge creation (University Affairs, 2017). PhDs are also vital components of academic institutional research, supporting global research networks, and are key contributors to the research outputs of their supervising faculty. PhD candidates provide critical function to the university community (teaching, research, fellowships) and service to broader public communities (volunteering, employment).

Canadian fulltime university professors (across all disciplines) are amongst the highest paid holders of academic positions worldwide (Altbach & Pacheco, 2015; Altbach et al., 2010). A PhD is a prerequisite to most fulltime academic faculty positions in Canada; therefore, it is not surprising that over 70% of PhD candidates (90% in Humanities) enter into PhD programs with the desire to secure fulltime academic career opportunities (Edge & Munro, 2015). However, less than 18% of Canadian PhD graduates (averaged across all areas of study) will go on to obtain a fulltime university faculty career. Women are underrepresented in fulltime professorship jobs in Canada, typically securing lower-ranking academic positions (sessional lecturers, demonstrators, technicians) than men (CAGS, 2018; Edge & Munro, 2015). There is an obvious career path disconnect between the goal of obtaining fulltime university faculty careers and the possibility of obtaining one (Walters et al., 2020; NSERC, 2017; Edge & Munro, 2015). Furthermore, although men and women should have the same career opportunities, research shows women may be at a greater career disadvantage post PhD than men due to career interruptions (family obligations, maternity, parental leave), workload, discrimination, stereotyping, and gender biases and this is especially true for women in STEM fields (Council of Canadian Academics, 2012; Statistics Canada, 2019a; Aiston & Fo, 2020). The main challenge is that women PhDs in STEM do not see themselves outside academia, crushing their dreams to have a position that is perceived worthwhile. So, why do women only think about professorship when many other opportunities exist?

The current landscape

In the late 1990s, Canadian universities, along with Canadian federal and provincial governments, predicted a shortage of highly qualified and trained academics (Maldonado et al., 2013). Concerns grew as to whether Canadian PhD programs would be sufficient to meet the predicted growing institutional enrollment demands, in light of the emerging knowledge, technology, and innovation driven economy (Maldonado et al., 2013). This led to a significant increase (73%) of PhD programs across Canada between 2002 and 2011 (Edge & Munro, 2015). Canadian higher education has continued to evolve rapidly in the last decade, with Canada currently producing over 7,000 PhD students each year (CAGS, 2018). However, Canada produces fewer PhDs when compared to its peer countries, ranking 14th out of 15 with Switzerland, Sweden and Germany in the top 3, and the U.S., Ireland, France, Canada, and Japan in the bottom 5 (Conference Board of Canada, 2013).

The traditional linear progression from undergraduate to PhD has shifted with PhD students enrolling at different life stages (non-linear paths) with an increase in returning (mature) students (Edge & Munro, 2015; Vasseur & VanVolkenburg, 2018). In 2015 (the most recent year of available data), there were 47,461 fulltime and 2,706 part-time PhD candidates enrolled in Canadian universities (CAGS, 2018). Of this, half were women, accounting for 48% of fulltime enrollments and 54% of part-time enrollments (CAGS, 2018). For fulltime PhD students (men and women but in varying proportions) the main areas of study are physical and life sciences, social and behavioral sciences, humanities, law, architecture, and engineering (CAGS, 2018). However, women PhDs were mainly enrolled in education, arts, health, communications, social sciences, law, environment, and conservation (CAGS, 2018).

After graduating from a PhD, many (both men and women) are pursuing one or more postdoctoral positions. Postdoctoral employment in STEM fields is changing in Canada, as the number of PhDs graduating each year is largely disproportionate to the available fulltime academic jobs requiring a PhD (Statistics Canada, 2020a; Edge & Munro, 2015). Yet, the evidence shows PhD programs continue to mentor students, especially women, for careers in academia despite the fact they are in low demand (Parker et al., 2015; Edge & Munro, 2015; Roach & Sauermann, 2017). Women are encouraged more than their male counterparts to pursue academic careers due to gender stereotypes and traditional gender roles (women perceived as nurturers, caregivers, teachers) as well as gender wage distributions in labour markets - as academic jobs are some of the highest paid positions for women in Canada (Statics Canada, 2019c; Urquhart-Cronish & Otto, 2019; Carroll et al., 2018). Although the literature suggests many PhDs, particularly those in STEM fields, are no longer seeking academic careers, this is not true for women in STEM (Walters et al., 2020; Maldonado et al., 2013; NSERC, 2017). This was also noted by the 2019 L'Oréal Prize Laureates who indicated they entered their PhD program with the desire and expectation to obtain an academic university career. They also indicated that labour market realities were not made clear to them during their studies, and felt they only received training and mentorship for academic careers.

Indeed, employment opportunities are more favourable for PhDs in STEM. However, women are significantly underrepresented in STEM representing only 25% of PhD degrees conferred and 23% of the work force (White & Massiha, 2016; Jonker, 2016; NSERC, 2017). With 75% of all PhD degrees in STEM going to men annually in Canada, this puts women at an immediate disadvantage when competing for jobs in STEM (Statistics Canada, 2019a; Reseau National Network, 2018). It is important to note that as academic positions are highly competitive, postdoctoral employment is now almost a must, especially in STEM. The latest postdoctoral fellowship NSERC competition (NSERC, 2020) shows that 449 applications were received (37% were women) and 111 fellowships were offered, (35% going to women). This puts women at a greater disadvantage as fewer are in fact entering competitive postdoctoral arenas. It is important to also note that the number of applicants to NSERC postdoctoral fellowships has declined since 2016 with 579 applications and 180 offerings to now 449 applications and 111 offerings.

There has been a shift in terms of where PhDs find employment. This could account in part for fewer applications to NSERC postdoctoral fellowships in STEM, but it may also be linked to the decline in academic position offerings. Between 2006 and 2016, Canadian universities reduced the number of assistant professors by 22% declining from 10,910 to 8,544 (Canadian Association of University Teachers, 2018). Many are replaced still by PhD but at the sessional level, most of whom did not go pursue postdoctoral employment. Walters et al. (2020 p. 6) noted 3-5 years after graduation, PhDs in STEM are "significantly more likely to be employed as sessional instructors, postdoctoral fellows, or in other temporary research-related jobs, than they are to be employed as full-time professors or researchers". With only 12% of full professors in STEM fields occupied by females, a reduction in

assistant stepping-stone career progression positions "will further impede women's progress to secure tenure professorships" (Canadian Association of University Teachers, 2018 p.2).

It appears that the current career pathways are no longer leading to academia, with less than 18% of PhD graduates (for Canada) securing positions as fulltime university professors (Edge & Munro, 2015; Roach & Sauermann, 2017). This shift has also been seen in the U.S. with less than 17% of PhDs securing fulltime university academic employment (The Economist, 2016). Globally, PhD employment has also diversified away from academic institutions (Wenqin et al., 2018). This, of course, significantly varies among disciplines. For example, PhD graduates in "the humanities and to a lesser extent social science are much less likely to secure employment and more likely to be unemployed within 2 years of graduating, compared to graduates from computer science, mathematics, physical sciences, and engineering" (Walters et al., 2020 p.5).

The good news is that Canadian PhD holders still have the lowest unemployment rate at 3.9% (same for men and women) compared with the Canadian average of 5.6% (Statistics Canada, 2020a, prior COVID-19 pandemic). Over the past decade, debates about the value of obtaining a PhD have been numerous (Jonker, 2016; Task Force on Competitiveness, Productivity and Economic Progress, 2011). Many critics argue Canada is inundating labour markets with too many PhDs, while others argue Canada is behind (ranking second last amongst peer countries) its global competitors in PhD output (University Affairs, 2017; Jonker, 2016; Conference Board of Canada, 2013). There is an agreement, however, that investments in producing a highly skilled labour force will be needed to enable new forms of economic productivity and to drive creativity and innovation needed for a more sustainable economic future (NSERC, 2017; Jonker, 2016; Waaijer, 2016). With only 2% of Canadian jobs requiring a PhD degree (i.e., university professor, biomedical research scientist, systems engineer), and with less than 1% of Canadians possessing one, the missing piece is a better understanding of skills that PhDs bring to the workforce, and where Canadian PhDs are employed, especially women in STEM (Edge & Munro, 2015).

Key statistics: gender and PhDs

48% of fulltime PhD candidates are women (all subjects)

52% of part time PhD candidates are women (all subjects)

25% of STEM PhDs graduates are women

23% of the Canadian STEM workforce (aged 25 to 64) are women

70% of PhD candidates want to go into fulltime academia

18% of PhD graduates actually go on to fulltime academia

- of that 22% are STEM PhDs
- of the 22% only 12% are women

0.4% of women STEM PhDs who secure full academic professorship

3.5% of men STEM PhDs who secure full academic professorship

< 25% of senior academic faculty leadership roles are held by women

What skills are unique to PhDs?

PhD programs require students to create new knowledge while pursuing discovery in their field of study at the highest level (Sinche et al., 2017). This level of mastery requires innovation and creativity, skills that are desirable across diverse labour markets (Sinche et al., 2017). The rigorous training of PhDs requires candidates to learn and adapt quickly, problem solve creatively and independently, gather relevant information efficiently, analyze and interpret complex data while demonstrating exceptional written and oral communications skills (Sinche et al., 2017). Globally, top executives are realizing PhDs bring talents to rapidly changing innovation and discovery-based economies (Entrepreneur, 2020). "PhD holders are a little better at looking at the bigger picture…with stronger literature review and technique" (Maymon et al., 2019 p.48). It is also "well documented that graduates of business, finance, economics, as well as…STEM fields, are more likely to obtain technical and applied skills that are easily recognized in the general labour market" (Walters et al., 2020 p. 6; Walters, 2004). A recent study by PricewaterhouseCoopers (2020) reported 63% of top executives are concerned about acquiring the skills needed to fill industry jobs especially in STEM related fields. In response, employers are moving away from focusing solely on job experience with more attention placed on a candidate's aptitude for quick-paced, adaptive learning and problem-solving; all essential skills held by PhDs (Entrepreneur, 2020).

Where are PhDs in Canada employed?

In Canada, labour force participation by women has risen significantly in the past four decades, with women expanding their academic fields of study and diversifying their career occupations (Statistics Canada, 2019b).

Canadian PhD (men & women) employment (all fields of study)

- Education: 40% employed in the education sector with just under 18% holding fulltime university faculty positions;
- Research and development: 17% employed in sciences outside of academic institutions;
- Business and finance: 15% employed as analysts, managers and researchers in the business and finance sector;
- Government: 11% employed as analysts, managers and researchers in government;
- Other sectors: the remaining 17% employed in tourism, art, culture, sales and trades

Source: Edge & Munro, 2015; NSERC, 2017

University of Toronto PhD alumni employment (all fields of study) 2000 – 2015

- Education: 51% employed in the education sector with 26% as tenure track professors, 3% as adjunct professors and 2% as fulltime teaching stream professors with the remaining 20% as university administrator, college and private school instructor, institutional researcher and postdoctoral fellow;
- Private: 18% employed in private sector mainly in biotechnology, pharmaceuticals, financial, agriculture and engineering;
- Public: 10% were employed in government mainly in research and development;
- Others: the remaining 21% are employed in not-for-profit, individual sector or unknown

Source: Reithmeier et al., 2019

The Edge & Munro (2015) and NSERC (2017) Canadian PhD employment by area of occupation are consistent with the University of Toronto's research by Reithmeier et al. (2019). The percentage of PhD graduates employed as tenure-track professors is 18%. The make-up of this 18% varies by field, with STEM accounting for the lowest portion (22%) of full professors and of this 22% only 12% are women (Canadian Association of University Teachers, 2018; Reithmeire et al., 219). In contrast, the percentage of STEM PhD graduates working in the Private Sector was highest at 34% (Reithmeier et al., 2019). An analysis of Ontario PhD graduates (from 2009) had similar findings with respect to STEM PhDs, with most working outside of academia in government, health, research, technology, and manufacturing (Jonker, 2016).

Where are Canadian women in STEM (college and university graduates) employed?

The most recent employment data (Canadian 2016 Census) group all STEM fields together resulting in very little information about PhDs numbers categorized by field. Since certain fields have very low numbers, reliable estimates (%) cannot be made by field and sex. Outside of academia the top five areas of occupation for women in STEM were information systems analyst, computer programmer, biologist, chemical technologist, and chemist (Statistics Canada, 2019a). A Statistics Canada (2019a) study reported that outside of academia, women in STEM are employed in industry and government sectors, mainly related to health and natural sciences such as biology. This same study finds employment for women with STEM degrees in non-STEM fields are in the following areas: specialized middle management occupations; professionals in the field of law; community and government services; business and finance; administrative and financial supervisors; and education services (Statistics Canada, 2019a). When looking at the top 1% of female Canadian earners, women with STEM credentials occupied the majority of positions which were concentrated in health care (Statistics Canada, 2019c). An important gender employment gap to note is within entrepreneurship. Women in STEM file fewer patents, start fewer businesses, are less likely to be self-employed, and are less successful in securing capital investment and other types of business funding when compared to their male peers (Fleisher & Marquez, 2019; Howe et al., 2014). This trend can also be seen beyond STEM in many global labour markets. Men in Organisation for Economic Co-operation and Development (OECD) countries are 75% more likely than OECD women to own a small business (Piacentini, 2013).

Path forward

As doctoral programs continue to produce 82% more PhDs than fulltime academic job availability, alternative career pathways need to be a more prominent discussion with PhD candidates, supervisors, and employers (Rudd & Nerad, 2015; Waaijer, 2016). Many women STEM PhD candidates are pursuing their degree without understanding career outcomes; they are lacking robust supervision and career mentorship opportunities; with many not encouraged to follow an alternate career path (beyond academia) by their supervisors (Gibbs & Griffin, 2013; Edge & Munro, 2015; Walters et al., 2020). This mismatch of desired academic career versus the more likely employment result (industry, government, private) is a factor (in addition to harassment, discrimination, etc.) contributing to why women leave STEM related fields post-PhD (Edge & Munro, 2015).

Statistics Canada (2019a) analyzed longitudinal data (2006 – 2016) to examine the occupational pathways of men and women with STEM credentials (aged 25 to 54). The research found 4 in 10 men were employed in STEM occupations, with less than 3 in 10 women employed in a STEM occupation. The research also found women moved to non-STEM occupations at a higher rate than men, with few returning after leaving. "Women are more likely to experience career interruptions because of

parenthood and often cite different reasons for leaving their fields than men, including family obligations, a lack of mentoring or guidance, a lack of flexible work hours, and the perception that science- and engineering-oriented workplaces are unfriendly to women" (Statistics Canada, 2019a p. 11). With a greater understanding of potential career paths beyond academia it is possible that most women would be encouraged to remain a PhD student and graduate knowing that other positions are possible.

As mentioned, many L'Oréal Women in Science Award (2019) laureates felt they were only trained and mentored for academic careers, with labour market realities and required skills not made transparent. Research indicates this is a common theme where women PhD candidates (especially in STEM) do not fully understand the career opportunities and limitations before committing to the pursuit of a PhD in STEM (Edge & Munro, 2015). Edge & Munro (2015) further argue PhD programs continue to mentor students, especially women (gendered role stereotyping) for careers in academia despite the fact they are in low demand. Gibbs & Griffin (2013) found PhD candidates who were interested in careers outside of academia had received more non-traditional skills development and training (such as experiential learning programs) compared to those who were only considering academic careers. The research also shows the amount (frequency of training) and types (general verses specific) of professional development opportunities relates directly to how PhD candidates come to realize they have a diversity of employment options (Gibbs & Griffin, 2013). If women are not having their mind open to the possibly of a diversity of career choices and are only fixated on a career in academia (academia only culture), they are likely to have a sense of disappointment in their career.

Academic institutions (supervisors, faculty, counsellors, administrators) need to be aware of career opportunities for women PhDs in STEM, and they must be transparent and supportive in preparing PhD candidates for career opportunities beyond the academy (St. Clair et al., 2017). There is also a concern that the core competencies and skills of women PhD in STEM do not match the requirements of Canadian employers (St. Clair et al., 2017; Roach & Sauermann, 2017). This is an important issue to address, as business leaders have indicated university PhD recent graduates enter the workforce with poor "soft" skills such as communication, with many skills of PhDs seen as irrelevant outside of the academic institution (Edge & Munro, 2015; St. Clair et al., 2017). There is a need for Canadian employers including public and private sectors to better understand the transferable skills of PhDs, as well as a need for PhDs to be able to translate and communicate the professional skills acquired through their PhD graduate training to potential employers.

The following section will explore the various avenues of solutions or considerations to better support women PhD in STEM to ensure they succeed beyond academia.

Considerations for institutions

Mentorship

The gender gap in university enrollment in Canada is closing. Women are surpassing men in some programs (mainly in social sciences and humanities); however, this is not the case for women in STEM fields who still continue to be largely underrepresented, making up only a quarter of enrollment (NSERC, 2017). The most influential timeframe for females in deciding to pursue a career in STEM happens in students between grade 7 -9 (NSERC, 2017). The determinants have less to do with cognitive ability (comprehension) and more to do with the levels of positive (confidence boosting) engagement, presence of role models, and mentorship opportunities in math and sciences (Statistics Canada, 2020b; NSERC, 2017). Girls and young women who participate in science and math related activities (science-based summer camps, science fairs, and competitions such as robotics) are 3 times more likely to consider a career in STEM (NSERC, 2017; Kolehmainen & Carnes, 2018). When young women see

women as role models involved and represented in these disciplines, their interest further increases (NSERC, 2017; Parker et al., 2015; Kolehmainen & Carnes, 2018).

Many universities have mentorship programs that usually focus only on academic mentoring, further perpetuating the idea that the only viable career option is academia. However, more needs to be done to help students identify non-academic alternatives. The visible presence of accomplished women scientists and researchers is needed to allow women in STEM the ability to envision what successful careers in STEM can look like and to see all possible career pathways including entrepreneurial, and private sector (Council of Canadian Academics, 2012; Kolehmainen & Carnes, 2018).

There are many ways to achieve this, starting with the conscious decision to include more women in professional development and mentorship programs. Stronger EDI policies can help ensure better representation of women, but to be effective, mentorship programs need to involve a diversity (age, gender, area of discipline) of mentors who can serve as trusted advisors making themselves available to students when they need support. For women in STEM, effective mentors can be men who are supportive of women pursuing various STEM pathways. This is important for three reasons:

1) with the number of women in STEM being low, many are overloaded with work demands;
2) there is a danger of symbolism and tokenism; the inclusion of the "token" women to create the appearance of inclusivity, and equity and therefore adherence to EDI policies; and
3) since men dominate most STEM career fields, possessing skills and knowledge in a diversity of sectors that could be readily shared with women through mentorship and collaboration, male mentors can promote the career advancement idea of "lifting while climbing".

Mentorship programs for elementary, high school, undergraduate and graduate students must be carefully designed and be adequate for the age brackets and the needs of the students. Social considerations must also be taken into account to ensure that students being mentored are not marginalized as being gifted or requiring special leniency as examples. This is especially important for younger students who have different social and peer pressures, with more potential consequences for standing out or receiving perceived special treatment.

The role of faculty and senior researchers

Supervising faculty have a responsibility to help students visualize career possibilities beyond academia. However, with enrollment in universities increasing and faculty positions declining (or not being filled), faculty are being spread thin with less time to devote to oversight and mentorship of students (Walters et al., 2020). As the pace of research is increasing, with larger collaborative teams involved, a higher reliance on "cascading mentorship" which involves a diversity of mentors (senior researchers and other faculty) is emerging as the new mentorship model to ensure relevant skill develop training of PhD students (Feldon et al., 2019 p. 20914). Feldon et al. (2019) suggest that by engaging PhD graduates, senior researchers and faculty from other departments in the mentorship of PhD candidates, a more holistic, hands-on training and professional development (including enhanced networking) learning ecosystem can emerge. To ensure women in STEM fields fully realize fulfilling and meaningful work post PhD, institutions should acknowledge the dynamic and changing role of the supervisor. Faculty need to better understand all required scope of work of a supervisor and the importance of unbiased supervision - research shows that many students felt supervisors were not receptive to professional development programs that distracted them from academic research (Maldonado et al., 2013; Scaffidi & Berman, 2011). Maldonado et al. (2013) also report PhD students are more likely to attend professional development events and workshops if supported by their institution, funding agencies, supervisors and research teams.

Understanding the career landscape

Less than a quarter of STEM PhDs end up in a career for which they were specifically trained, i.e., biology (Baker, 2015). It is essential for academic institutions to match career and skill development programs with the needs and career expectations of their students. For PhDs, important requirements in terms of career objectives are work that is interesting, intellectually challenging, supports personal development, and fosters societal contributions (Gibbs & Griffin, 2013; Waaijer, 2016). The desired career outcomes of PhDs are therefore nuanced and go beyond just simply securing employment. Dialogue and opportunities to broaden the scope of students' career understandings should be happening at early academic stages and continue throughout the academic journey. Maldonado et al. (2013) found that when students were aware of labour markets (viable employment options) related to their degree prior to entering a program, they were better prepared for employment realities (those beyond academia).

There are numerous job opportunities for women STEM PhD graduates, however they lack information about which career options are available to them (Gibbs & Griffin, 2013; Cheeky Scientist, 2020). As STEM PhDs are recognized for having strong problem solving and analytical skills, the following alternative careers in STEM are increasing in demand: analyst positions in innovation-based sectors such as biotechnology, software, consumer electronics, and pharmaceuticals; project managers in technology based companies; quantitative data analysis, financial research, and statistical modeling in financial institutions; business operation research analysis in medical and heath care fields; science and innovation liaison; and science communication specialists are a few of the job sectors trending upwards in terms of viable employment options for women PhDs in STEM (Cheeky Scientist, 2020).

By improving the understanding of where recent PhD graduates obtain employment, institutions can tailor career development opportunities to balance the career aspirations of students with labour market realities. In order for institutions to stay current with labour market trends, it is recommended that they involve insight from STEM alumni and employment specialists. Increasing experiential learning exposure for PhD candidates through networking, especially with women STEM alumni, may assist in understanding non-academic career trajectories. Given the nature of laboratory work as independent and often self-isolating, women in STEM could benefit from increased development of skills needed for collaboration in diverse contexts. Institutions should be maintaining relationships and tracking career outcomes of program alumni, not only to draw upon for expert panels and internships, but to track career statistics (an identified data gap) and to promote career options that reflect current labour market trends and skills (Scaffidi & Berman, 2011). This would also support increased mentorship to provide women STEM PhD candidates with career guidance.

Professional development and career preparation

Although globally, labour markets are beginning to acknowledge that PhDs have the aptitude to work effectively in "complex knowledge environments characteristic of contemporary societies", this shift continues to be slow (Rudd & Nerad, 2015 p. 5). PhDs need to demonstrate a combination of skills including transferrable ones (i.e., skills that apply to all job sectors) (Rudd & Nerad, 2015). When assessing PhD graduate training in areas of transferrable skills such as technical writing, working in teams, managing people and communication, Rudd & Nerad (2015) report this component to be insufficient. Outside of academia, employers have cited the lack of transferable skills such as communication, team building, collaboration and project management in PhD holders (Rudd & Nerad, 2015; Walters et al., 2020).

A diversity of skills sets is an important asset when competing for STEM careers outside of academic institutions, as many employers do not understand the skills of PhDs beyond highly specialized research (Walters et al., 2020). Encouraging PhD students to engage in extracurricular activities that build their transferrable skills would be valuable. For example, the University of Toronto encourages

undergraduates in STEM fields to develop networking skills early in the academic process with a focus on extracurricular activities to help improve transferrable skills such as communication and teamwork, “one of the best ways that STEM students can prepare for careers, whether academic or non-academic, is to get involved beyond courses and/or research,” (The Varsity, 2020). In addition, the University encourages STEM PhD students to combine their science knowledge with other employable skills including supplemental training in areas such as business, financial and law. Linking student participation to additional academic certifications and acknowledgment has proven to be successful in terms of increasing student uptake (Scaffidi & Berman, 2011; Maldonado et al., 2013). It is important to note, these approaches may place additional burden and stress on PhD candidates, and a more holistic approach should come from the institutions and be at the core of PhD programming.

In 2013, the National Institute of Health (NIH) created the Broadening Experiences in Scientific Training (BEST) and Award program. The goal of the program was to “broaden the view of what constitutes the scientific enterprise” and provide institutional support to shift training program cultures (Baker, 2015 p. 92). The main objective of the program was to change the perception that science jobs outside of academia are “second class” by opening up views of what successful careers could look like (Baker, 2015 p. 92). Although coming from the biomedical field, the BEST program was developed to be adaptable to fit all university programs across all disciplines. Program structure included networking directly with diverse expert panelists from a variety of sectors to explore multiple science career trajectories, day-long workshops, and internships to support experiential learning. It was also designed to help support faculty (including supervisors) acceptance and knowledge of non-academic career paths (Lenzi et al., 2020).

There is an immediate need for institutions to better prepare graduate students that have transferrable skills beyond research methods and design, to include project management, scope of work prioritization, technical writing skills (not just academic writing), science communication and how to function and perform as part of a team. Maldonado et al. (2013) report that universities, department heads and supervisors are all deficient in providing opportunities for transferrable skills development, and programs offered are too general and not tailored to address current labour market realities. There is also a need for PhD graduate students to understand what transferrable skills are and the necessity of developing and marketing them as part of successful transitions to professional careers (Rudd & Nerad, 2015; Walters et al., 2020).

To better support women in STEM post PhD, professional development and career preparation programs and activities should consider a wide range of possible professions and have representation from those sectors as part of workshops, panel discussions, career fairs and other experiential career development opportunities. Given the competing priorities and time constraints many women STEM PhD students contend with, graduate studies departments should provide a diversity of engagement options. Skills training and professional development programs should be inclusive and accessible including sessions hosted in the evening and on weekends, with on-line options (both synchronous and asynchronous) to better accommodate schedules. Supervisors, including the entire research team, should be aware of and promote these opportunities to their students to show support and encouragement for the pursuit of a wide range of career options. Collaboration and information-sharing through public communication is a key pillar of the UNESCO (2017) Recommendation on Science and Scientific Researchers, pointing to the need for institutions to rethink the way professional development is planned.

Summary of considerations:

1) Increase the visibility of women role models and mentors at all stages of the academic process who are not only academic researchers (professional networking groups outside of academia) i.e. Women in Bio; WIMDI (Women in Male Dominated Industries);
2) Increase visibility of other types of careers in STEM for women, with a focus on the transition point between elementary and high school, to allow young women early realization of STEM career possibilities;
3) Increase programming aimed at broadening the understanding among faculty, supervisors and PhD graduate students of current career landscapes and labour markets in STEM fields;
4) Provide training and professional development opportunities for supervisors (and other faculty) to ensure enhanced understanding by supervisors of their key role in ensuring students are adequately prepared for all possible career options including those beyond the academia;
5) Expand professional skills development training beyond traditional approaches, including experiential learning and integrated work placement/internship opportunities;
6) Increase availability of transferrable skills development programs, effectively marketed (specific outcomes) to incentivize student attendance linked to professional development credential programs whereby students are recognized for training efforts via transcripts;
7) Increase career transition preparation to facilitate the move of PhD candidates from academic institutions to outside the academy with increased attention on the marketing of transferrable skills to help counterbalance the myth that PhDs are narrowly focused in research only and are lacking in experience, or alternatively as holders of the highest academic achievement, are overqualified;
8) Increase Institutional tracking of career outcomes of PhD STEM alumni (by gender) to better inform professional development and transferrable skills training, experiential leaning programs, and networking opportunities.

Final thoughts

The small but cumulative effects of the underrepresentation of women along the entire STEM career path (from elementary school through to post doctorate) has resulted in substantial negative overall impacts on women in STEM and on economies (Aiston & Fo, 2020). Research confirms a diversity of gender in the workforce drives up productivity and innovation; when women leave STEM careers, innovation and discovery suffers (Parker et al., 2015; Barres, 2006). A part of the solution of increasing women's opportunities in STEM careers (and retaining them in STEM careers) is increasing the engagement of girls and young women in STEM related activities during the transition between elementary and high school as seen as most impactful (NSERC, 2017). An area for further high impact resourcing is the investment in extracurricular STEM opportunities (science fairs, robotics competitions, technology camps, etc.) for young girls. It is equally important that these opportunities have a diversity of mentors and role models represented including women and other underrepresented groups including Indigenous Peoples, LGBTQ2+ and persons with disabilities. The importance of STEM engagement opportunities and the exposure to female leaders in STEM cannot be overstated in terms of its critical importance (Aiston & Fo, 2020). Practices of inclusion and equity should carry through to graduate school for women in STEM with a focus on increased visibility of women role models representing a diversity of career sectors. Professional engagement opportunities should focus on building strong transferrable skills while teaching students how to market both academic and professional skills into fulfilling careers, regardless of the career path chosen.

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