HAMILTON COMMUNITY FOUNDATION

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Encouraging Girls to Pursue STEM Fields in Hamilton, ON

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INTRODUCTION

It is widely perceived that men perform better than women in the fields of science and math. While this is not true from an abilities point of view, there are documented gaps in the numbers of women pursuing Science, Technology, Engineering and Mathematic (STEM) education and careers. Analysis by the Council of Canadian Academies (CCA) (2015) reveals that Canadian women "have made rapid gains in post-secondary education in Canada to the point that women now outnumber men in undergraduate and master's programs, and are close to parity with men at the doctoral level overall". However, these gains are only made in the fields of humanities, social sciences, education and life sciences, where women outnumber men in these fields. On the other hand, women are not attaining degrees in the fields of physical sciences, computer sciences, engineering and mathematics at the same rate as men (Halpern et al, 2007; CCA, 2015).

In fact, data from Statistics Canada (2013) and from MasterCard (2014) show that:

- Women comprise only 28% of post-secondary STEM graduates in Canada
- Among STEM graduates aged 25 to 34, women accounted for 59% of those in science and technology programs, but accounted for 23% of those who graduated from engineering and 30% of those who graduated from mathematics and computer science programs
- For all the Canadians who choose a career in technology, only 18% were women
- For the others who did not choose a career in technology, 29% of women stated that it was because they did not believe they had the skill set for the job and 11% said they weren't encouraged to develop skills in science and math

Women are represented as one group but women from racial and sexual orientation minorities face more barriers in North America (Williams et al, 2014). It is interesting to note, however, that more immigrant women have STEM degrees:

- Young immigrant women aged 25 to 34 are twice as likely to possess a STEM degree than their Canadian-born cohorts (23% versus 13%) (CCA, 2015)

From the aforementioned information, it is clear that the question which should be asked is why are women not pursuing degrees and careers in STEM? To answer this question, one must reverse back and examine the trajectory of gender disparity in the STEM fields. STEM education beings as early as primary education and continues throughout schooling years. Some research even suggests that STEM education could be introduced in pre-school programs and activities (Heckman, 2008). It is somewhere along this education route that girls and young women seem to "leak from the pipeline" leading to STEM careers.

RESEARCH DESIGN

Purpose

This research project was commissioned by Women for Change (W4C) to continue informing W4C's action on its dual focus: enhancing the lives of women and girls in Hamilton and increasing the capacity of women as philanthropists. Specifically, W4C proposed to conduct this research project to explore areas and ways to improve the local

situation regarding inspiring and supporting young women to enter and pursue careers in the STEM fields.

There are four main areas that are explored in this research project:

- Issues affecting young women interested or engaging in STEM careers. Specifically for young women in elementary, middle and high school
- A local environmental scan related to STEM education and career (in terms of the literature, research, services and organizations) available for young women in Hamilton, Ontario
- Best practices (toolkits, strategies and programs) related to inspiring, engaging and supporting young women to pursue STEM fields
- Current and potential opportunities in Hamilton for W4C to act locally – already identified in existing reports and as identified by the research

Research questions

What are the barriers affecting girls and young women (elementary to high school) from engaging with the STEM fields in terms of education and careers?

What are the current services available to encourage these girls and young women to pursue the STEM fields in Hamilton, ON?

What are the best practices to inspire, engage and support girls and young women to pursue the STEM field?

Inclusion criteria

- Girls and young women in elementary, middle and high school
- Issues and services pertaining to Hamilton and the GTA
- Best practice research can be national and/or international
- Research in the last five to ten years

Search strategy

An initial Google scan was conducted with the keywords (girls, women, STEM, education, school, gender gap, Hamilton, Ontario, Canada) to identify organization, people, news articles and reports pertaining to the research questions. Further, a Google Scholar search was conducted with the same keywords to identify research papers and journal articles. Additionally several searches were conducted on the following databases and journals:

- Education Resources Information Center (ERIC) database
- International Journal of STEM Education (Springer)
- Journal of STEM Education: Innovations and Research
- Journal of Research in STEM Education (J-STEM)

ANALYSIS & FINDINGS

Barriers affecting girls from engaging in STEM fields

Overall, the issue of bias and discrimination against females in STEM education and careers is of a cyclical nature. The inherent bias toward women in the STEM workplace trickles down into the school system and everyday life but it could also be said that the systemic bias amplifies as it travels through the educational institutions.

Early on at the preschool and primary level, toys, educational materials and activities for STEM are mainly geared towards boys. These toys, such as building blocks (lego), help develop spatial memory and design (SACHA, n.d.; Halpern et al, 2007). Toys marketed towards girls are usually of the "home making" and socializing nature, which while not intentionally harmful, reinforce gender stereotypes and begin the idea of career differentiation based on gender (SACHA, n.d.).

Gender discrimination from teachers, family and the overall cultural environment is pushing girls away from STEM subjects and into more feminine subjects (Hazari et al, 2013). Teachers play an important role in shaping students' opinions about STEM subjects, especially in middle school. The notion that "girls are not good in math or science" is a harmful one as it would unconsciously provide teachers and parents with an excuse to not push their daughters as much as they would their sons in STEM subjects. There is also a bias in teaching and grading; STEM subjects are taught through a curriculum that caters to the spatial learning of boys and not towards the problem solving techniques that girls tend to prefer (Halpern et al, 2007). Boys are graded higher in math and science than girls with the same performance level. If care is not taken in planning and approaching STEM subjects in a way that is appealing for all students (including girls), these subjects would lose popularity and students will be uninterested to pursue them further (Halpern et al, 2007; Hazari et al, 2013).

While getting girls into the STEM fields is improving, there are still problems in encouraging them to grow their interests and pursue these fields further after high school. Capturing and retaining interest is hindered when STEM subjects are not explicitly related to careers. Also the lack of "visible" mentors from the STEM fields in the community can have a detrimental effect. A present mentor, not necessarily a female role model, but someone who can have a constant influential relationship has a positive effect on students to continue being connected to and to consider careers in STEM (Hazari et al, 2013).

Moreover, to continue to empower girls and young women to pursue STEM careers, the promise of finding and maintaining jobs in STEM fields after graduation should be the next obstacle to address. It is already established that there are not enough women in STEM careers. The main issue is thought to be a pipeline issue i.e. if more women are to be employed in STEM fields, more girls should be enrolled in post secondary STEM education. If one follows this logic, then one could conclude that the issue is that not enough girls and young women are enrolling (CCA, 2015; Schwartz, 2015). However this is proving to be incorrect as enrollment is comparatively increasing. In fact, young Canadian women (aged 25 to 34) have a higher percentage of STEM degrees (39%) than women aged 55 to 64

(23%), thus showing that the gender balance is slightly shifting (StatCan, 2013; CCA, 2015). It is fair, then, to conclude that it is the number of women who choose STEM as a career that is not increasing. Even more concerning, some studies show that the number of women who have STEM careers is actually decreasing (Williams et al, 2014; Schwartz, 2015).

Another theory explaining the issue is that women are choosing to leave their careers in STEM for more family life balance rather than biases in the workplace, but new research shows that this is untrue (Williams et al, 2014). Women are not choosing to leave; rather institutional laws and regulations that are not family-friendly put women in an unfavourable situation when compared to their male counterparts. It is bias, not pipeline issues or personal choices that push women out of STEM and it manifests and intensifies at different levels depending on women's ethnicity and sexual orientation.

Williams et al (2014) explain that there are four types of biases and discriminations that women in STEM experience on a regular basis throughout their career. The first is the "prove-it-again"; where women have to provide more evidence of competence than men to be seen as equally capable. Thus, reflecting the stereotype that women are not fit to be scientists (Moss-Raucusin et al, 2012). The second is the "tightrope"; where women find themselves walking the fine line between being seen as too feminine to be capable or too masculine to be likable. Therefore if a woman is seen as too feminine, she would be pushed to take more dead-end, administrative and housekeeping roles. On the other hand, if a woman is seen as too masculine by showcasing assertiveness and self-promotion, she would be thought of as angry, disliked by colleges and may face backlash (Williams et al, 2014). The third is the "maternal wall" which Correll et al (2007) describe as the most damaging gender bias triggered by motherhood as women are assumed to lose their professional commitment and competence once they have a child. The opposite is also true as women who maintain their work commitments without apparent struggle are penalized and criticized for not being visibly more involved with their children. The fourth gender bias explained is the "tug of war"; where the competitive nature of STEM careers and the predominantly masculine atmosphere would fuel conflict between female colleges. The competitiveness around the coveted female position on teams, panels, grant applications, etc. causes isolation as the already few women are pitted against each other (Moss-Raucusin et al, 2012; Williams et al, 2014).

The lack of understanding mentors, the hostile environment and laws, and lower compensation coupled with the aforementioned biases result in women either abandoning STEM completely or working outside of the corporate/ institutional sectors. Williams et al (2014) also address the "double jeopardy" of being a woman and a minority in STEM. Women who identify with an ethnic or a sexual orientation minority or both have intensified experiences of isolation and discrimination with the addition of language barriers and cultural differences. CCA (2015) estimates that the proportion of STEM-educated women working in STEM-intensive occupations (26.9%), an already low number, is lower than the proportion of men (43.6%). Biases in the workplace therefore need to be addressed as the gender gaps in STEM become more apparent in the professional setting.

Local barriers affecting girls from engaging in STEM fields

In addition to the general issues discussed above, there are city-specific barriers in Hamilton. First, there is a limited amount of extracurricular and after school specialized STEM programs/camps available for girls and young women. The current programs that are available are not very well advertised. Also several organization provide similar programs therefore duplicating the efforts and concentrating them in a narrow geographic area rather than collaborating to cover diverse areas and populations in the city. There is also inequity in the distribution of opportunities to attend these programs. Most of the camps that are identified through this research project appear to be paid camps and are held in a university setting. This can deter participants from low socio-economic areas or those who have no previous encounter with post-secondary education from participation. (A list of STEM programs and camps specifically catering to girls in Hamilton can be found in Appendix A).

Furthermore, there is a lack of local visible mentors (as explained above). While there are many female scientists, engineers and others in STEM fields based in Hamilton they are not easily accessible to school students. Having a formal city-wide mentorship program for STEM fields would be beneficial in this instance, especially if the school boards were to collaborate with post secondary educational institution such as McMaster University or Mohawk College.

Acknowledging the limitations of this research project due to the short time period and the reliance on published written material, the search did not uncover any city- or school boards- specific studies regarding STEM education for girls. This limits the understanding of the extent of the gender gap and barriers in Hamilton and may affect the implementation of recommendations as Hamilton's population and other characteristics may differ from those of studies done in United States and the United Kingdom.

RECOMMENDATIONS

For preschool and elementary girls, encouragement to engage in STEM starts at home. Parents are encouraged to introduce educational toys that make math fun and promote spatial problem solving (SACHA, n.d.; Halpern et al, 2007). This should translate to elementary school by making science fun through experimentation, introducing the scientific method and providing role models early on.

Middle school is where students form solid opinions on subjects, so continuous engagement of these students is important with in-school and extracurricular STEM programs to introduce engaging real-life applications of STEM. Therefore, building programs and camps which are equitable, accessible and girl-centred is extremely important (Halpern et al, 2007).

Teachers' influence is important at this stage as well. Teachers have to be positive and encouraging and provide helpful feedback while explaining to the students that STEM skills can be acquired gradually (Williams et al, 2014). Teachers' professional development is therefore an essential vehicle to build competencies to recognize ways in which they might reinforce stereotypes associated with girls and STEM. It also equips them with the

techniques to challenge stereotypes and unpack the work of STEM professionals in STEM areas with low female representation (Hill et al., 2010; CCA, 2015).

In addition, an appropriate and effective STEM curriculum is equally important in supporting and engaging students. Tsupros et al (2009) define a STEM curriculum as "An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy." Updating current curricula to match this universal definition would further enhance the STEM education quality. Another recommendation from the research is to start all-girls classes for science and math. This has low power as an evidence-based recommendation if done on its own it but helps increase confidence, provides a safe space for exploration and builds support systems if done in concurrence with the aforementioned support (Halpern et al, 2007; Shapiro et al, 2012).

For high school students, discussing career paths and interests and highlighting STEM fields is important whether through family, teachers or guidance counsellors (Halpern et al, 2007). In addition, the research identified the strongest evidence-based recommendation for engaging young women with STEM was by discussing the gender gap in STEM with them (Hazari et al, 2013). The honest dialogue encourages self-awareness and ownership of the issues as well as the potential solutions, empowering female students to break free from the barriers. Moreover, introducing strong female role models in STEM, while on its own has low power as an evidence-based recommendation, can be very helpful if coupled with all the strategies discussed. A constant mentoring relationship that is open to discussing the value of STEM education explicitly is most helpful. These strategies, in addition to the continuous support and encouragement from teachers and parents, are an evidence-based formula for success.

For more information, the Institute of Education Sciences in the United States compiles the best available evidence to form a practice guide for educators and provides recommendation that can be used to encourage girls in the in STEM fields (Halpern et al, 2007). A copy of these recommendations can be found in Appendix B.

Finally, knowing that the increase in female enrollment in STEM education through time is alone not enough to alleviate the gender gap in STEM careers, one must remove the biases and discrimination women experience in the workplace to promote gender parity in STEM. CCA (2015) recommend inclusive working culture at the career level as an important step in the right direction. Starting from human resources, bias-free recruitment training will ensure that females are not overlooked based on gender. Other strategies may also include promoting family-friendly corporate/institutional laws and policies such as accessible child care and flexible rather than fixed career progression models. Additionally, female targeted grants, sponsorship and mentorship initiatives also help retain female STEM professionals (CCA, 2015).

Current possible opportunities in Hamilton

Specific to the City of Hamilton, all-year equitably accessible camps/ programs could provide enriching experiences for girls and young women interested in STEM. Some classes should be female only as girls thrive in such an atmosphere if done in combination with positive mentorship and with discussions on gender underrepresentation to help with students' self-realization and empowerment. A network of service providers should be established to collaborate and support these camps/ programs to intensify efforts and avoid duplication. Moreover, mentorship from older students and STEM professionals from McMaster University and Mohawk College could be provided to build positive relationships and more insight into the STEM careers themselves.

Another initiative that is in line with the Hamilton Community Foundation and Women for Change's goals is providing scholarships for female students who are interested in pursuing the STEM fields for post secondary education. This opportunity is relatively faster to implement and can eliminate the significant financial burden a STEM education entails on students and their families.

Additionally, the research identified a single STEM training opportunity for teachers in the Hamilton school boards. Sponsoring continuous teachers' professional development and training in STEM education and empowerment would fill a gap of services in the city. Most girls site science teachers as the influence to pursue a STEM career, therefore it is important to train teachers, especially male teachers, to alleviate the disempowerment experienced through gender mismatch (Hazari et al, 2013).

In conclusion, while the literature search can point at general trends and extensive systemic barriers in Canada, North America and the world, the data and recommendations cannot be used with full confidence for the specific case of Hamilton. More nuanced local research should be conducted to arrive at a better understanding of the barriers experienced by girls and young women who pursue or want to pursue STEM education and careers in Hamilton. The anti-oppression and anti-discrimination model should start with the research as this study should be community-based; involving the students, parents, teachers and the school boards to gain personal, institutional and systemic insight. The study should also be conducted with mixed methods; including interviews, focus groups and questionnaire to eliminate engagement barriers. Key informants to interview could include McMaster University organizations and professors such as Women In Science and Engineering (WISE) and Dr. Pippa Locke, assistant professor in the Department of Chemistry & Chemical Biology, 3M National Teaching Fellow, 2014-2015 OCUFA Teaching Award recipient. Similarly, Mohawk College has an abundance of experts in the STEM field such as Christine Bradaric-Baus(Vice-President, Academic). Insight from industry and corporate partners such, as ArcelorMittal Dofasco, would help in identifying barriers in STEM careers. Together, the Hamilton community's investment in girls and young women's STEM education will not only benefit the girls themselves but the city and its people will also reap the social and economic rewards.

APPENDIX A

Current programs/ courses/community partners/ advocates in Hamilton:

- Girls Learning Code Day (girls ages 8 -13) through Ladies Learning Code
- STEM camp, private organization, PA day camps (both boys and girls)
- McMaster University (different faculties):
    - Big Ideas science and engineering summer camps (boys and girls)
    - Women In Science and Engineering (WISE), Let's Talk Science (LTS) and the Graduate Women in Physics & Astronomy (GWIPA) host "Turn Girls on to STEM" event (grade 8 and 10), all girls
    - Venture Girls Club (grades 1 to 8), all girls
    - Go Eng Girl (grades 7 to 11)
    - Learning Enrichment Advancement Program (L.E.A.P.) (Gr. 9-12)
    - Go CODE Girl event
    - Yes SHE Can! Camp (grades 6 to 8), all girls
    - Girl Guide Day, teaching girl guides about STEM
    - McMaster also has engineering entrance scholarships for 10 students at $2500
    - Other initiatives through Actua
- Sexual Assault Centre (Hamilton & Area) (SACHA) is an advocate and speakers from SACHA discuss gender and STEM
- City of Hamilton has general science camps/ after school program through the recreation centers (both boys and girls)

APPENDIX B

The Institute of Education Sciences in the United States compiles the best available evidence to form a practice guide for educators and provides recommendation that can be used to encourage girls in the in STEM fields (Halpern et al, 2007).

Recommendation 1: Teach students that academic abilities are expandable and improvable.

- Teach students that working hard to learn new knowledge leads to improved performance.
- Remind students that the mind grows stronger with use and that over time and with continued effort, understanding the material will get easier.

Recommendation 2: Provide prescriptive, informational feedback.

- Provide students with feedback that focuses on strategies used during learning, as opposed to simply telling them whether they got an answer correct. This strategy encourages students to correct misunderstandings and learn from their mistakes.
- Provide students with positive feedback about the effort they expended on solving a difficult problem or completing other work related to their performance.
- Avoid using general praise, such as “good job,” when providing feedback to individual students or an entire class.
- Make sure that there are multiple opportunities for students to receive feedback on their performance.

Recommendation 3: Expose girls and young women to female role models who have succeeded in math and science.

- Invite older girls and women who have succeeded in math- or science-related courses and professions to be guest speakers or tutors in your class.
- Assign biographical readings about women scientists, mathematicians, and engineers, as part of students’ assignments.
- Call attention to current events highlighting the achievements of women in math or science.
- When talking about potential careers, make students aware of the numbers of women who receive advanced degrees in math- and science-related disciplines.
- Provide girls and young women with information about mentoring programs designed to support students who are interested in mathematics and science.
- Encourage parents to take an active role in providing opportunities for girls to be exposed to women working in the fields of math and science.

Recommendation 4: Create a classroom environment that sparks initial curiosity and fosters long-term interest in math and science.

- Embed mathematics word problems and science activities in contexts that are interesting to both boys and girls.
- Provide students with access to rich, engaging relevant informational and narrative texts as they participate in classroom science investigations.
- Capitalize on novelty to spark initial interest. That is, use project-based learning, group work, innovative tasks, and technology to stir interest in a topic.

- Encourage middle and high school students to examine their beliefs about which careers are typically female-oriented and which are typically male-oriented. Encourage these students to learn more about careers that are interesting to them but that they believe employ more members of the opposite gender.
- Connect mathematics and science activities to careers in ways that do not reinforce existing gender stereotypes of these careers.

Recommendation 5: Provide spatial skills training.

- Recognize that children may not automatically recognize when spatial strategies can be used to solve problems and that girls are less likely to use spatial strategies than boys. Teach students to mentally image and draw spatial displays in response to mathematics and science problems.
- Require students to answer mathematics and science problems using both verbal responses and spatial displays.
- Provide opportunities for specific training in spatial skills such as mental rotation of images, spatial perspective, and embedded figures.

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