



ENGAGING GIRLS IN STEM:

A Knowledge Synthesis of 16 Canadian Non-Profit Organisations' Programming

Louise Couceiro
l.couceiro.1@research.gla.ac.uk



This research was funded by the UKRI and Mitacs as part of the UK-Canada Globalink Doctoral Exchange Scheme 2022-2023

CONTENTS

02

Acknowledgements

03

Executive Summary

05

Introduction

08

The Canadian Context

- Girls' Performance and Engagement with STEM: A Snapshot
- Approaches and Initiatives: A Brief Overview
- NPOs: An Integral Component

10

Methodology

11

Engaging Girls with STEM: Key Themes

- Connection and Confidence
- Access and Exposure
- Program Design
- Beyond Girls

26

Recommendations

28

Conclusion

29

Links and Resources

31

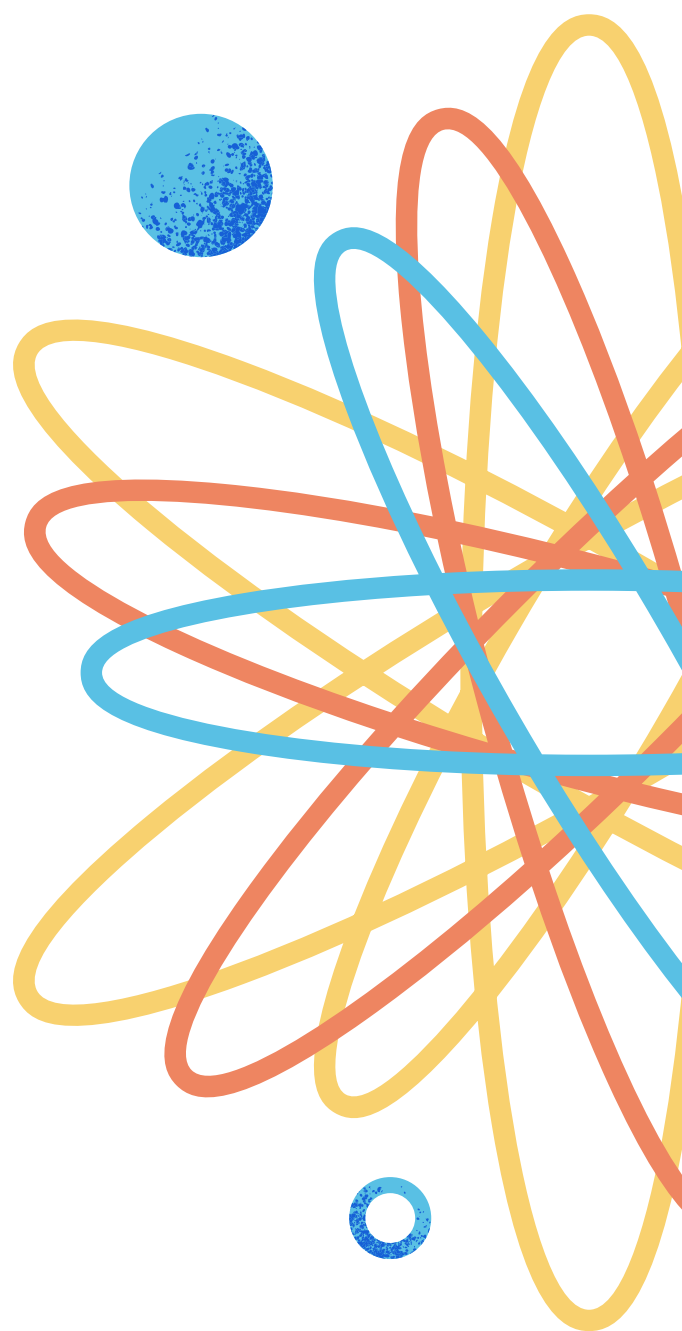
References

35

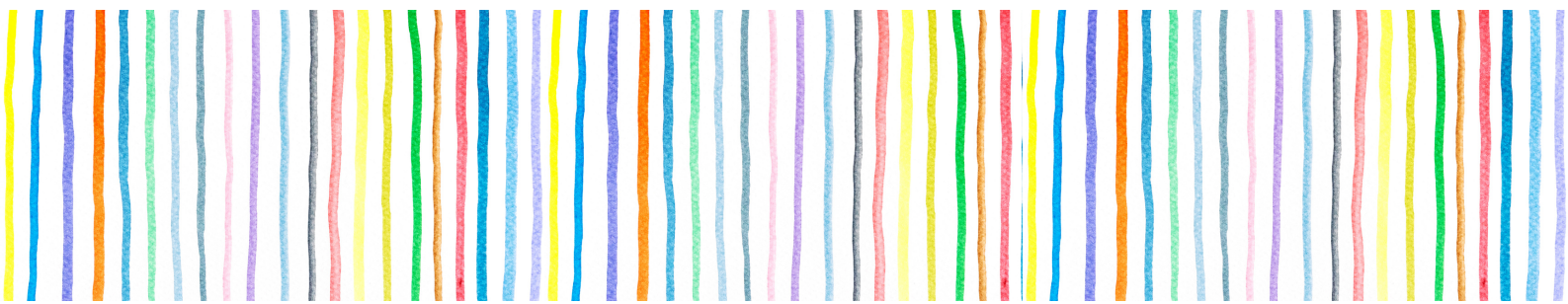
Appendices

ACKNOWLEDGEMENTS

With sincere thanks to Mitacs and the UKRI for funding this work through the UK-Canada Globalink Doctoral Exchange Scheme; to Professor Nicki Hedge and Dr Barbara Read (University of Glasgow) for supporting my application; to Associate Professor Natalie Coulter (Director of IRDL, York University) for her expert and attentive supervision throughout; and to all the representatives I spoke with across the 16 organisations. Your generosity and eagerness to support this knowledge mobilisation project has been extraordinary.



EXECUTIVE SUMMARY



Worldwide, men continue to outnumber women in most STEM (Science, Technology, Engineering and Mathematics) fields (Teo, 2022).^{*} This is problematic and warrants redress for a number of reasons. Not only is it important that, in their early years, girls feel confident and comfortable engaging with STEM if they so wish, but diversity in STEM ultimately ‘leads to better problem-solving, expands the talent pool and is important for long-term economic growth’ (Gibbs, 2014). Ensuring women have the opportunity to thrive in STEM-related fields also helps narrow the gender pay gap and improves women’s economic security.

In Canada, there has been a high degree of policy concern and extensive research undertaken to improve women’s representation in STEM (Wall, 2019). The Government and its federal partners continue to implement initiatives to aid girls’ participation in this area (Government of Canada, 2021).

Similar to UK initiatives, non-profit organisations (NPOs) are a crucial component of Canada’s strategy. My knowledge synthesis highlights how Canadian NPOs are encouraging girls to explore STEM through their programming and outreach work.

This summary report is based on information gathered between 26th September and 16th December 2022. I met with representatives from 16 Canadian NPOs who have programming, initiatives and strategies that aim to encourage girls to engage with STEM, and undertook a scoping review of information presented on the organisations’ websites.

^{*} My use of the terms, ‘women’ and ‘girls’, is inclusive of anyone who identifies as such.

Information gathering highlighted that there are a constellation of factors organisations tend to consider as they seek to positively impact girls' engagement with STEM:

- Cultivating a sense of belonging
- Building girls' confidence
- Ensuring access to role models
- Increasing exposure to possibilities and facilitating access for all
- Fun, hands-on, exploratory approaches
- Relatability and relevancy of the programming
- Engaging with parents, caregivers and other adults
- Engagement in co-educational spaces

The report concludes with a series of recommendations:

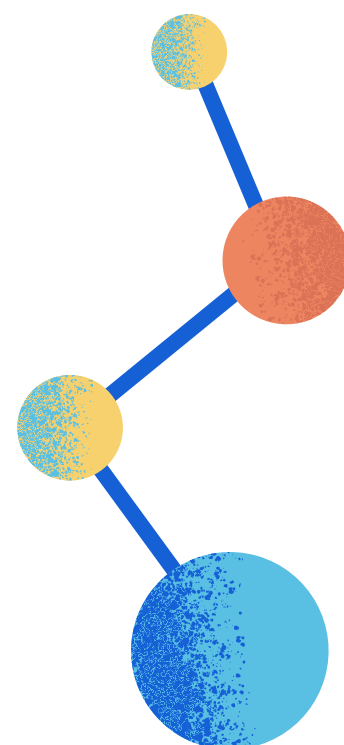
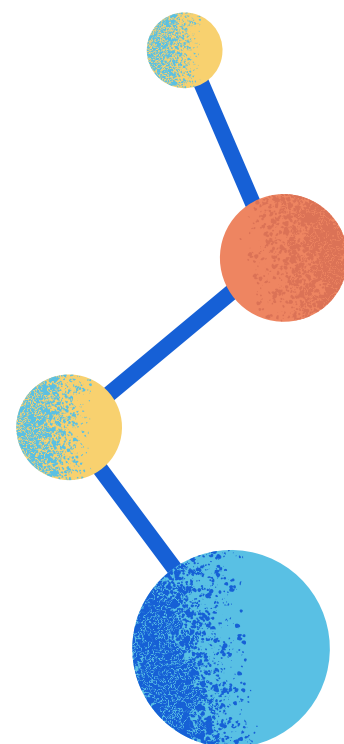
- Programming must be developed using an intersectional lens.
- Organisations need robust systems in place to evaluate the efficacy and impact of their programming.
- The development of digital or hybrid programming can support organisations who seek to broaden their reach and/or enhance their accessibility.
- Consistent sources of funding are required to develop sustainable, barrier-free, long-term programming.
- More attention needs to be given to engaging girls' wider networks (peers, families, communities, etc.)
- Organisations should continue developing programming that is specific to their particular geographic, social, economic and cultural contexts. Developing programming in consultation with girls can help ensure programs are relatable and relevant.
- Both girls-centred programming and gender-inclusive programming can positively impact girls' engagement with STEM.
- Cultivating a sense of belonging for girls is clearly important. However, it should not be assumed that this can only be achieved in girls-only spaces.
- Supporting girls to feel more confident is important for increasing girls' engagement with STEM, but interventions should not focus on this singular issue.
- Organisations should engage with girls to gain insight into their experiences, and/or consult research highlighting girls' perspectives.
- Organisations must be careful not to eschew the realities of systemic and structural inequities/challenges when promoting individual success stories.

INTRODUCTION

According to a 2017 UNESCO report, only 35% of STEM students in higher education globally are women. 'This gender disparity is alarming, especially as STEM careers are often referred to as the jobs of the future, driving innovation, social wellbeing, inclusive growth and sustainable development' (UNESCO, 2017). In the early stages of schooling, girls are just as engaged with STEM activities as boys (Teo, 2022), but the influence of social norms, social expectations and gender stereotypes often preclude further engagement (Microsoft, 2017; Teo, 2022). Worryingly, a Europe-wide research study found that girls tend to become attracted to STEM between the ages of 11 and 12, but this interest drops off significantly between 15 and 16, meaning governments, teachers and caregivers only have four or five years to nurture girls' passion (Microsoft 2017: 5).

Similar to many counties, Canada is striving to ameliorate the gender disparities in STEM, with NPOs working tirelessly to drive and support these efforts. The variety of programming currently being delivered is impressive (see Table 1 for a summary of the programming offered by the 16 NPOs I engaged with for this knowledge synthesis). However, throughout my conversations with NPO representatives, it quickly became apparent that whilst there is sometimes communication between NPOs who are geographically close, there is little engagement with NPOs in other areas of the country. This is regrettable given the wealth of knowledge that could be shared.

The purpose of my knowledge synthesis is two-fold. Firstly, I aim to provide NPOs, in Canada and beyond, with insight into the work of other organisations who are committed to supporting girls to engage with STEM. Secondly, based on the information gathered, I present a series of recommendation for future practice. While the recommendations have been developed with NPOs in mind, they are broadly applicable to any organisation or initiative invested in supporting girls to engage with STEM.



Organisation	Location	Girls*-Centred Programming	Classroom Workshops	Camps	Singular Community Events	Mentoring Programs for Girls	Singular Careers Events	Youth-Led Initiatives	Online Resources	PD for Teachers	Other Girls-Centred Programming
Girls Inc. of Upper Canada	Brockville, On	X	X	X	X						
Girls Inc. of Northern Alberta	Fort McMurray, AB	X	X	X	X			X			Scholarship awards for post-secondary STEM students and Operation SMART: multi-session program
hEr VOLUTION	Toronto, ON	X		X		X	X	X	X		
Mouvement Montréalais Les Filles & Le Code (MMFC) (part of CMTL)	Montréal, QC	X	X			X	X		X		
Brilliant Labs	Atlantic Canada	Currently developing	X	X	X		X	X	X	X	
Science Centres											
Montréal Science Centre	Montréal, QC	X	X		X				X	X	
Ontario Science Centre	Ontario, ON	X	X	X	X		X		X	X	
Science World	Vancouver, BC	X	X	X	X				X	X	
Libraries											
Okanagan Regional Library	Okanagan, BC				X				X		
NSERC Chairs											
WVWEST (UBC)	Kelowna, BC		X	X	X				X		
WISEatlantic	Halifax, NS	X		X	X		X		X	X	
Other University Alliances											
Science ALIVE (SFU)	Vancouver, BC	X	X	X	X	X			X	X	Power STEM girls: multi-session program
UBC Geering Up Engineering Outreach	Vancouver, BC	X	X	X	X	X			X	X	Technovation: supporting girls to participate in global competition and parent/guardian information sessions
National Organisations											
Let's Talk Science	National		X		X		X		X	X	
Scientists in School	National		X		X				X	X	
Founded by Youth											
STEM Sorority	Vancouver, BC	X			X		X	X	X		

Table 1 - Summary of NPO Programming

If all or part of the programming within a category is specifically girls-centred, this is highlighted in yellow. NPOs that do not offer girls-centred programming pay attention to the needs and interests of girls in other ways.

Girls*-Centred Programming	<p>Programming advertised specifically for girls</p> <p>*Many NPOs that have girls-centred programming have an inclusive view of the word, 'girl', stating that they welcome trans, genderqueer and non-binary youth to participate in these events and initiatives</p>
Classroom Workshops	Sessions delivered either in-person or virtually for classrooms of students. Classroom workshops might also take place outside of schools, for example, at science centres
Camps	Events that are longer than one-day. Some are over-night camps, some are day-camps that run for 4 or 5 days
Singular Community Events	One-off events delivered in the community (at community centres, after-school clubs, libraries, etc.)
Mentoring Programs for Girls	Programmes that offer sustained engagement with a mentor working in a STEM-related field
Singular Careers Events	<p>One-off events with youth, focused primarily on providing knowledge and advice about STEM careers.</p> <p>(Many of the NPOs have careers-focussed components embedded within other parts of their programming)</p>
Youth-Led Initiatives	Initiatives focussed on girls and STEM that are run by youth
Online Resources	Resources available on the NPOs websites. Resources might include media developed by the NPO (for example, podcasts and videos on their YouTube channel) or links to external resources, such as STEM education apps, information about other organisations, or literature and research pertaining to young people and STEM
PD for Teachers	Professional development opportunities for teachers. These range from access to online resources, to extensive credentialed programmes, to one-day workshops and training sessions
Other Girls-Centred Programming	Girls-centred programming that does not fit within any other category

Table 2 - Definitions for Table 1 labels

THE CANADIAN CONTEXT

Girls' Performance and Engagement with STEM: A Snapshot

Looking broadly at young Canadians' performance in mathematics and science, there is reason to be buoyant. The latest Programme for International Student Assessment (PISA) report (2018) reveals that Canadian students continue to score higher than the OECD average in mathematics, science and reading. However, these scores have been declining gradually since the early 2000s.

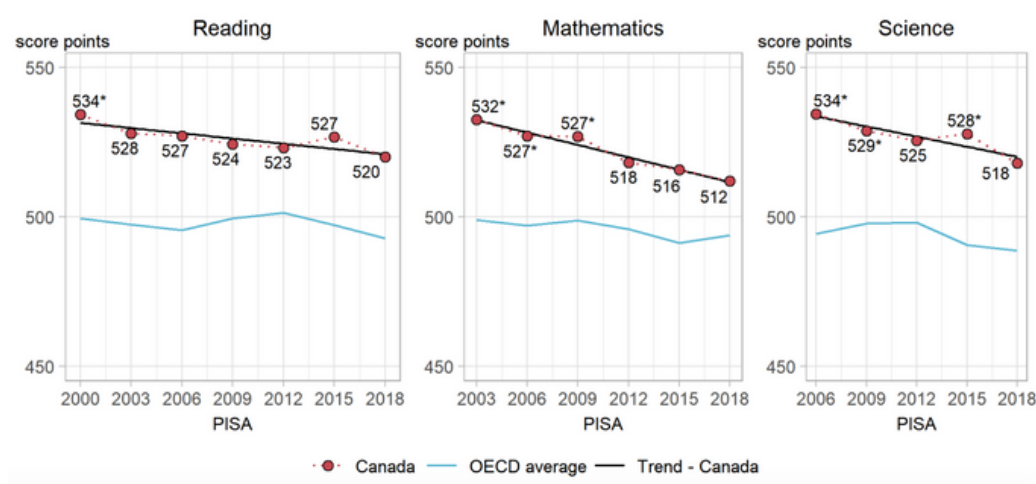


Figure 1 - Trends in performance for Canada (PISA, 2018)

Comparative to the average across OECD countries, Canadian girls are performing relatively well in STEM: Canada has a higher proportion of top-performing girls in science, and a lower proportion of low-performing girls. Girls and boys are shown to perform similarly in science, though boys continue to outperform girls in mathematics. Yet, strikingly, amongst high-performing students in mathematics or science, around one in three boys expect to work as an engineer or science professional at the age of 30. For high-performing girls, it is one in seven. Whereas some 7% of boys expect to work in ICT-related professions, only 1% of girls have this same expectation.

Looking beyond school, there is a significant decrease in representation as young women transition from high school to postsecondary education, and from there into the labour market (Wall, 2019). Women make up less than 25% of people employed in STEM careers and although 34% of Canadians with a STEM degree are women, they make up only 23% of Canadians working in science and technology (Statistics Canada, 2016). Women of colour experience a 'double-bind' of race and gender, with black women making up just 2.5% of professionals in the field of computer and information systems (Gagnon and Milan, 2020). Therefore, whilst it is important to pay attention to girls' engagement early on, it is crucial to recognise that the category of 'girls' is not homogenous. Girls have multiple, intersecting axes of identity which can coalesce to further marginalise and affect access to STEM.

Approaches and Initiatives: A Brief Overview

In Canada, the underrepresentation of women in STEM fields has continued to attract attention from policymakers, educators, researchers, young people, industry professionals and parents/guardians. Canada has many programs and initiatives aiming to improve gender inequities in STEM including, but not limited to, awareness-building campaigns; research and evaluation studies; outreach programs delivered by non-profit and charitable organisations (sometimes in collaboration with private-sector companies); teacher training programs; and governmental initiatives. For example, the Government of Canada collaborates with numerous partners and invests in programs to help girls and women engage with STEM, including the Chairs for Women in Science and Engineering (CWSE) program. However, as many initiatives are localised, it is difficult to get a holistic view of the collective impact these initiatives have on girls' engagement.

NPOs: An Integral Component

Undoubtedly, NPOs play a crucial role in furthering girls' and women's engagement with STEM, and Canada has seen significant growth in STEM outreach over the last decade (Let's Talk Science, 2022). There are many NPOs offering programming that seeks to engage girls, and youth more broadly, in STEM. In many ways, these organisations are uniquely placed to help affect change. Existing outside of formal education systems, these organisations can provide young people with more bespoke, alternative ways to explore STEM. However, there is a lack of connection between and among NPOs. This means opportunities for knowledge exchange and collaborative evaluation work on which initiatives are most impactful, are almost non-existent.

METHODOLOGY

The purpose of my knowledge synthesis is to document the programming, initiatives and strategies of 16 Canadian NPOs, aiming to encourage girls to explore STEM. I review the range of offerings; how programs are designed, implemented and evaluated; and how virtual spaces are being utilised. The synthesis was guided by the following questions:

- What programming and approaches are Canadian NPOs undertaking to engage girls with STEM?
- How are programs implemented and how is their impact evaluated?
- What are the opportunities and challenges for NPOs aiming to engage girls in STEM?
- How are the NPOs using virtual spaces to engage girls in STEM?

To address these questions, the following actions were undertaken:

A scoping review of studies on girls and STEM initiatives in Canada over the past ten years

An Internet search for current NPOs in Canada offering programming designed to encourage youth, especially girls, to explore STEM. This culminated in outreach to 31 NPOs, of which 16 responded. Short descriptions of the 16 NPOs are provided in [Appendix I](#)

A scoping review of the information presented by the 16 NPOs on their websites, about their programming

Engagement with representatives from the 16 NPOs (video conferencing calls and in-person meetings). The list of guiding questions utilised during these conversations is included in [Appendix II](#)

Thematic analysis of the website information and conversations with NPO representatives

ENGAGING GIRLS WITH STEM

KEY THEMES

My scoping review of the NPOs’ programming and conversations with representatives highlighted a constellation of factors the organisations tend to consider as they seek to positively impact girls’ engagement with STEM. I have distilled these considerations into eight key themes, grouped within four categories:

CONNECTION AND CONFIDENCE	PROGRAM DESIGN
Cultivating a sense of belonging	Fun, hands-on, exploratory approaches
Building girls' confidence	Relatability and relevancy of the programming
ACCESS AND EXPOSURE	BEYOND GIRLS
Ensuring access to role models	Engaging with parents, caregivers and other adults
Increasing exposure to possibilities and facilitating access for all	Engagement in co-educational spaces

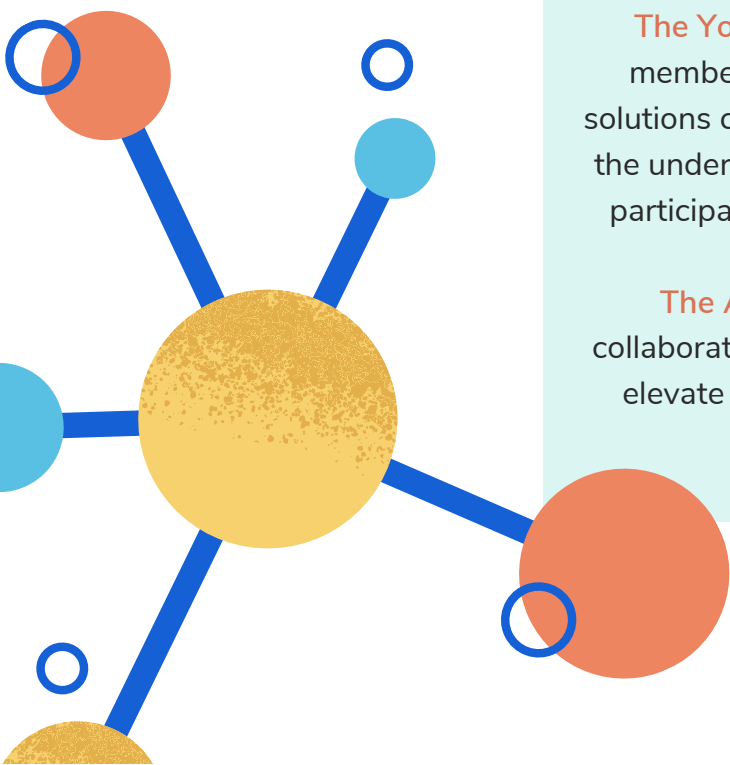
While these themes are broadly consistent with those already established in the research literature, this synthesis includes specific examples of how NPOs are actively and consciously engaging with them. I also include further insights that provide alternative or further ways of thinking about the various themes.

CONNECTION AND CONFIDENCE

Cultivating a sense of belonging

The importance of girls feeling a sense of belonging and connectedness was a repeated point of discussion throughout conversations with representatives, and is reflected in a lot of the programming offered by the NPOs. Notably, most of the programming, with the exception of certain mentoring schemes and online resources, involve girls gathering together. In fact, this was the impetus for a group of high school students to set up their own NPO, STEM Sorority. The founders spoke passionately about wanting to create an environment where girls interested in STEM could connect with others and feel a sense of belonging.

Representatives of NPOs often recalled moments where girls had reported feeling isolated in their STEM classes at schools. Further, of their gratitude for opportunities to connect with other girls who share similar interests and passions. One NPO representative noted that their pre- and post-program surveys always include questions regarding participants' sense of belonging – as participants continually state that feeling a sense of belonging is important to them, they continually measure participants' perceptions of how they have performed in this area.



hEr VOLUTION have two youth-led initiatives, both of which provide participants with opportunities for further connection and an even greater sense of belonging.

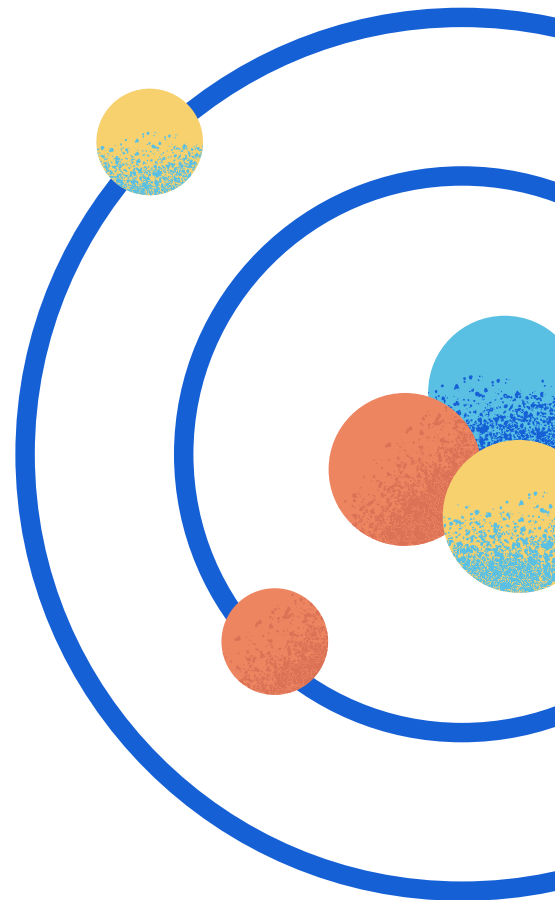
The Youth Committee is made up of a diverse team of members who support the organisation with ideas and solutions concerning issues pertaining to youth in STEM from the underserved communities. Members attend and actively participate in Board meetings, and represent the interests and needs of external constituencies.

The Ambassador Program involves young women collaborating to plan and execute various campaigns to help elevate the benefits of STEM for young womxn who are facing multiple barriers.

A sense of belonging is particularly relevant for underrepresented minorities' motivation in STEM fields: 'Pervasive negative stereotypes and common social and environmental cues can signal to members of these groups that they do not belong, which reduces their motivation to pursue these fields' (Master and Meltzoff 2020: 156). Psychological studies have found that sense of belonging and connectedness with others can help instigate girls' and women's interest in STEM subjects (Thoman et al., 2012; Good, Rattan, and Dweck, 2012; Id-Deen, 2017; Lewis et al., 2017; Marzocchi, 2016; Master, Cheryan, and Meltzoff, 2016; Thoman et al., 2012). A study in Sweden also found that girls are more likely to retain their STEM interest when they are surrounded by other girls who like STEM (Raabe, Boda and Stadtfeld, 2019).

It is human nature to desire belonging and connectedness. That many girls experience increased interest and engagement with STEM when they feel part of a welcoming and supportive community is thus unsurprising. However, this is not to say that establishing a sense of belonging can only occur in girls-only spaces. Interestingly, a recent study revealed that adolescent girls feel a greater sense of belonging in groups that hold less traditional stereotypical beliefs (Barth, Masters and Parker 2022). This suggests that while girls might feel a greater sense of belonging in girls-only groups, some might feel a sense of belonging in other spaces where stereotypical beliefs are largely absent. As I discuss in [Beyond Girls](#), other relations including parents/guardians, grandparents, siblings and male peers, can be influential in creating and maintaining spaces where girls can feel a greater sense of belongingness.

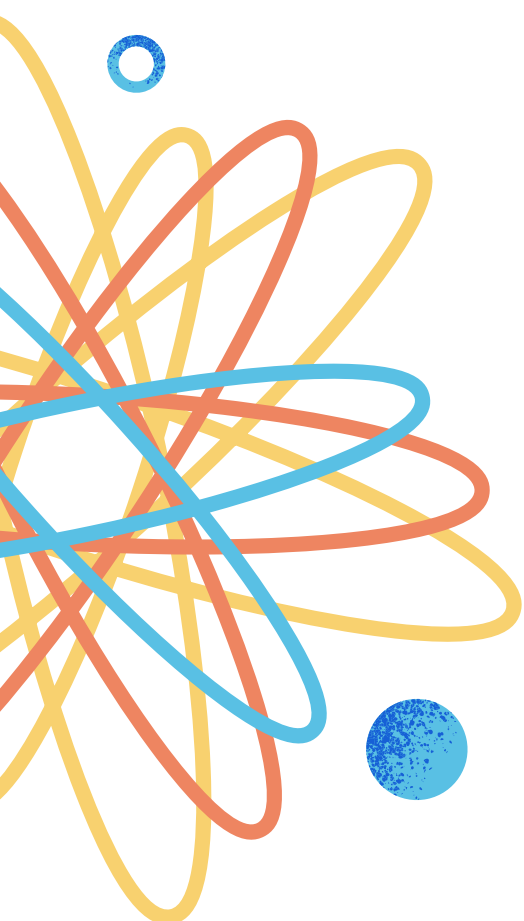
*A study in Sweden
found that girls are
more likely to retain
their STEM interest
when they are
surrounded by other
girls who like STEM*



Building girls' confidence

It is frequently asserted in news articles, opinion pieces, and blogs that girls' lack of confidence is a leading cause of gender disparities in STEM. Often, these pieces are underpinned by research positing that many girls begin to lose confidence in STEM during adolescence (Microsoft, 2018; Orenstein, 2013; Ypulse, 2018). For example, building upon research they had undertaken in Europe in 2017, Microsoft conducted another study (2018) in the US, reporting that girls' confidence in coding and programming undoubtedly decreases as they get older. Another study undertaken by YPulse (2018) with 1,394 young people and their parents/guardians in the US found that twice as many high school boys think they would be successful in an engineering career compared to their female peers. Findings such as these are concerning, especially given that the beliefs individuals hold about their capabilities and future outcomes undoubtedly affect their decision-making (Fogg-Rogers and Hobbs, 2019a). They are also frustratingly paradoxical given girls' higher performance in STEM subjects (Stoet and Geary, 2018).

Unsurprisingly, one of the key priorities for many of the NPO representatives I spoke with was encouraging girls' confidence in STEM, with various strategies being implemented. Role models are indispensable to this endeavour, as girls' lack of confidence is inextricably linked to delimiting stereotypes and beliefs. Indeed, while there are many explanations for gendered differences in STEM confidence, one that holds particular salience is that girls are likely to be affected by the widely held cultural belief that boys are better at STEM than girls (Archer and DeWitt, 2015; Archer et al. 2013; Master, Meltzoff and Cheryan, 2021). Therefore, exposing girls to women who defy widely-held socio-cultural beliefs regarding women's (lack of) science capability, can be highly effective.



Scientists in School aims to ensure students participate in numerous workshops, as longitudinal research undertaken from 2013 to 2019 by Western University in collaboration with the organisation, highlighted that children's participation in multiple workshops acts as a lever to maximise confidence and interest in STEM. The impact on girls was particularly notable: 'Six workshops over three years increased positivity for understanding of STEM done in class, as well as interest and confidence in STEM of Grade 8 girls by approximately 15% over the cohort with two workshops, bringing them even with the boys and shifting the gender gap from sizable to insignificant' (Scientists in School 2021: 14).

Many of the NPOs also try to facilitate multiple opportunities for STEM engagement, as prolonged participation in STEM activities can have positive impacts on confidence (Heaverlo, Cooper and Laanan, 2013; Scientists in School, 2021). Furthermore, some representatives noted that girls feeling a sense of belonging was necessary for promoting confidence. They work hard to facilitate connection and collaboration, incorporating a lot of group work and opportunities for informal/casual conversation into their programming.

Ironically, however, girls' lack of confidence can be a barrier to their participation in programming designed to cultivate their confidence in STEM. Two representatives spoke about this in the context of advertising – if girls already feel under-confident, they are unlikely to be attracted to an event that seems predominantly STEM-orientated. Therefore, they try to garner girls' interest by marketing their events in relatable and relevant ways, perhaps highlighting the general area they will exploring as opposed to the explicit STEM-element(s).

Ultimately, girls' confidence is important, though there is research contesting the extent to which girls' confidence can and should be expounded as the leading explanation for girls' engagement with STEM subjects and women's underrepresentation in STEM careers (Bennett, Bawa and Ananthram, 2021; Litzler, Samuelson and Lorah, 2014; Moote et al., 2020). For example, Litzler, Samuleson and Lorah (2014) highlight that STEM confidence can and does vary at the intersection of race/ethnicity and gender. They find that, after controlling for personal, environmental, and behavioural factors, Black undergraduate women in engineering demonstrate similar levels of confidence as their White male peers. They suggest a number of potential explanations, including that these students may; unlike their counterparts, draw on mostly internal sources of motivation. Studies such as this are a sobering reminder that we should be weary of talking about girls' lack of confidence in STEM in broad, generalised terms. While confidence is clearly a contributing factor, it is not the only factor. The confidence landscape is far more nuanced than sensationalist headlines sometimes suggest.

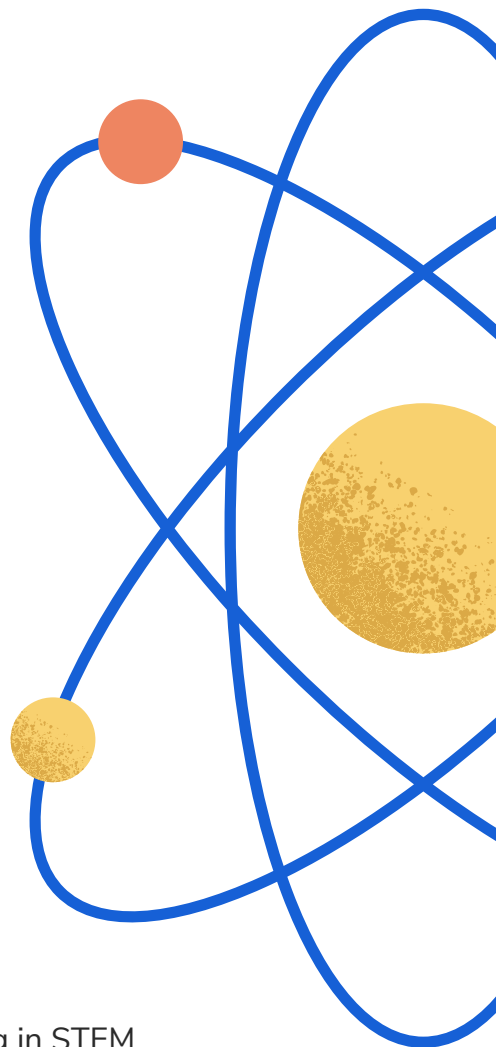
*While confidence
is clearly a
contributing
factor, it is not
the only factor.
The confidence
landscape is far
more nuanced
than
sensationalist
headlines
sometimes
suggest*

ACCESS AND EXPOSURE

Ensuring access to role models

Role models are one way in which delimiting discourses around girls and women in STEM can be challenged. Indeed, there is substantial research to corroborate the oft-cited claim that girls benefit from having female role models in STEM, positively affecting interest, confidence and engagement (Dasgupta and Asgari, 2004; Fogg-Rogers and Hobbs, 2019b; González-Pérez, Mateos de Cabo and Sáinz, 2020; Microsoft, 2018; 2017; Stout et al., 2011). Analysis of results from 78 US studies involving the Draw-a-Scientist test (DAST) – a tool utilised to investigate children’s perceptions of scientists – finds that although the percentage of female scientists drawn has increased since the 1960s, children remain more likely to draw a male scientist than a female scientist as they get older, with girls more likely than chance to draw a male scientist beginning around age 10 (Miller et al., 2018). Clearly, socio-cultural narratives about what girls and women can and should do persist, and early interventions (a point I return to in [Increasing exposure to possibilities and facilitating access for all](#)) are important. Despite the ‘Catch 22’ situation whereby role models are needed from fields where there is a significant lack (Fogg-Rogers and Hobbs, 2019a), all NPOs prioritise the incorporation of role models in a variety of ways.

As part of their programming, many of the NPOs invite women working in STEM to engage in long-term mentoring schemes, to deliver sessions and workshops on particular topics, and to participate in careers events. A number of representatives I spoke with placed emphasis on role models being relatable. Specifically, being relatable in a way that goes beyond signalling markers of identity, such as gender, race and ethnicity. Demonstrating empathy and forging meaningful connections with those who share similar experiences was deemed important. One of the benefits of longer-term mentoring programs is that there is more time for meaningful connections and relationships to grow and evolve.



This said, meaningful exchanges can occur in singular events, especially if making space for honest and authentic conversation is prioritised. Representatives told me stories of girls asking role models about the ‘nitty-gritty’ of their experiences: “What’s it like working with all men?”, “Do you have any regrets?”, “How do you balance work with having a family?”, “Is it hard being a woman in STEM?” These questions reveal that girls have a deep understanding that being successful in STEM is about more than just confidence. A review of socio-psychological research-based interventions into girls’ engagement with counterstereotypical role models finds that studies have failed to evidence significant change in girls’ aspirations for counterstereotypical occupations following a brief exposure to gender-counterstereotypical role models (Olsson and Martiny 2018: 6). In other words, it is not enough to put a female scientist in front of a group of girls and assume they will be inspired on account of her gender. Therefore, facilitating opportunities such as this, where young people can engage with role models who are authentic and unafraid to talk about the more challenging parts of their experiences, can be very valuable.

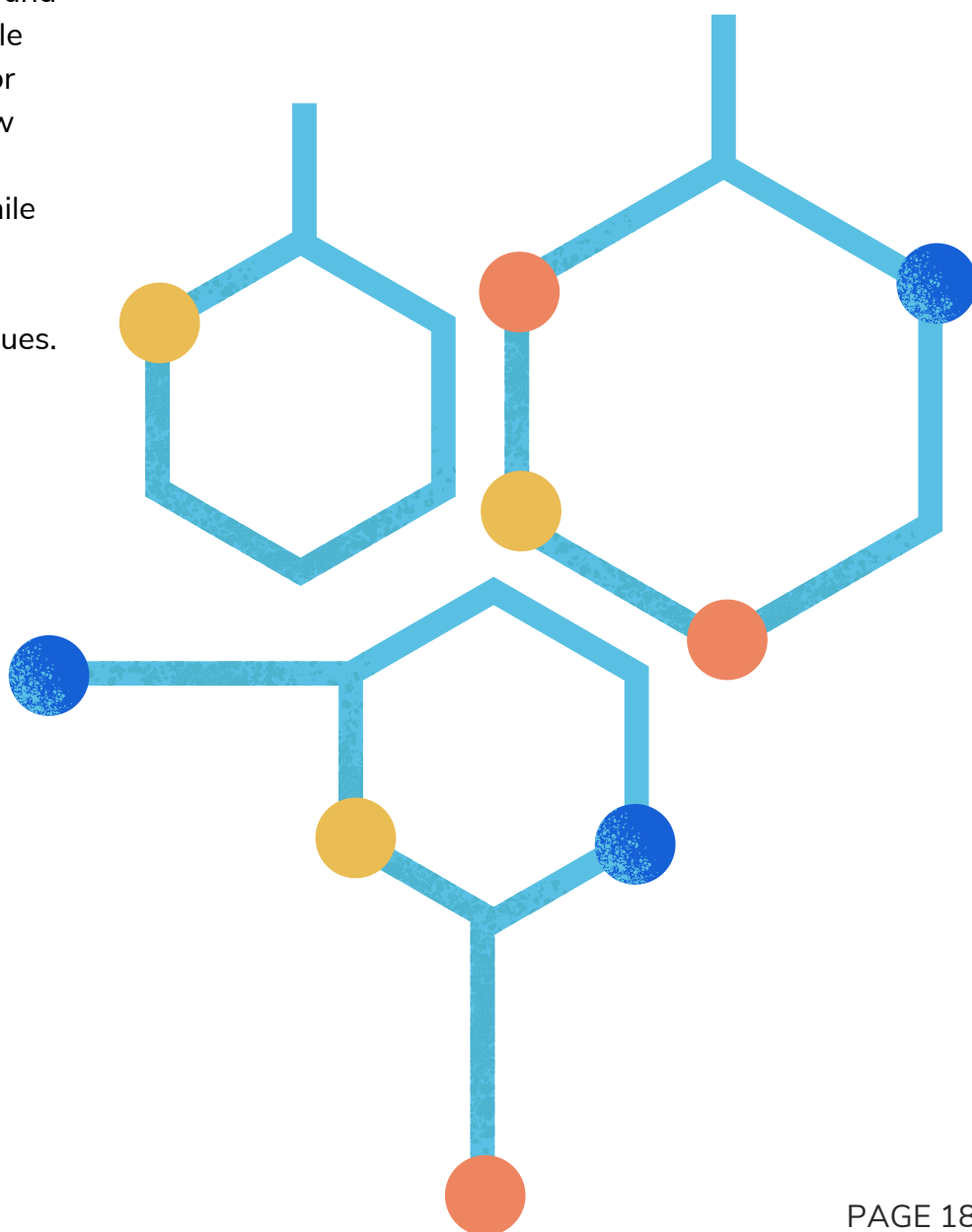
Some representatives called attention to the benefits of having role models to support program delivery who are close in age to the participants. Some observed participants seeming more at ease when engaging with role models closer in age to themselves, perhaps because they are more likely to have recent points of connection and shared experiences. Moreover, these young role models are able to develop their own mentoring and leadership skills through these experiences, and can often feel a sense of pride in supporting and inspiring others. Ensuring girls have exposure to women pursuing or working in STEM-related fields at varying stages was also deemed important, as it can provide a more holistic understanding of individuals’ journeys and trajectories.

In 2020-21, MMLF delivered the **Future Leaders in Tech** program. It consisted of three components: Inspire (a series of workshops and conferences delivered for students by recognised professionals in the field of technology); Support (20 ambassadors guided by mentors to design and deliver technological workshops for younger students); and Radiate (ambassadors delivered the workshops to younger students).

‘The intergenerational aspect was hugely successful. The college ambassadors loved engaging with the younger students’ (Kadidia Haïdara, MMLF, 2022)

Encouraging young people to be aspirational is important and role models can be hugely helpful in this regard. It is with good reason that the adage, 'if you can see it, you can be it', is often recited and reiterated with such zeal. Being open about how structural and systemic inequities can make this challenging, however, is equally important. If young people are not aware of these realities and they do not meet the markers of success set out for themselves, they might feel that they themselves have failed (Gill and Orgad, 2015). Therefore, role models might think about, or continue to think about, how they can encourage girls' engagement with STEM while also supporting them in navigating the realities of systemic challenges and issues.

Being open about how structural and systemic inequities can make this challenging, however, is equally important. If young people are not aware of these realities and they do not meet the markers of success set out for themselves, they might feel that they themselves have failed



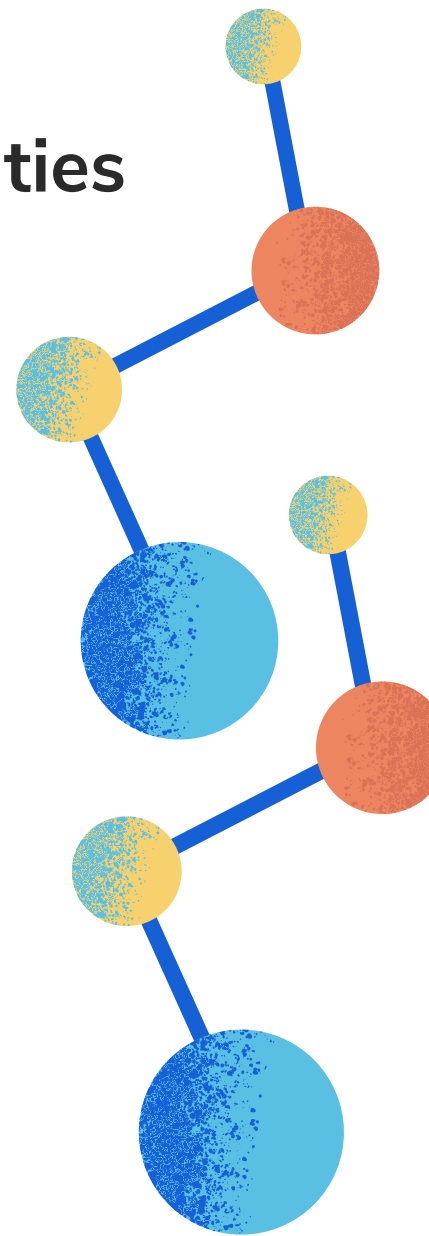
Increasing exposure to possibilities and facilitating access for all

Some NPO representatives noted that, time-and-time again, internal evaluations highlight girls' lack of knowledge around possible STEM-related careers. They said that many girls simply do not know what possibilities exist; an observation corroborated by scores of studies. For example, Microsoft (2017) found that girls' knowledge of how to pursue a STEM career begins to rapidly decline during high school. Research has also demonstrated the positive impact of early exposure to possibilities in STEM (Maltese and Tai, 2010; Master et al., 2017; Master and Meltzoff 2020).

A lot of the NPOs' programming is designed to provide girls with exposure to a broad range of career possibilities in STEM. For example, one-day events often include representatives from a variety of fields who run activities and workshops with participants, and engage in conversations about their STEM journeys and experiences. Some NPOs have a suite of online resources that highlight a variety of potential career possibilities, and others hold career events with the view to widening girls' exposure to various STEM fields. Needless to say, role models are integral to this exposure – if girls see women doing jobs and engaging in work they did not know existed, this can expand their understandings of what possibilities are 'out there'.

However, it is not the case that girls simply need to know what possibilities exist. Many girls need access to enrichment programs and extracurricular opportunities in order to gain this knowledge. Factors including socio-economic status and geographical location can make this very challenging. For example, girls living in urban areas are more likely to have easier access to opportunities and greater exposure to a variety of career possibilities than those living in more remote, rural locations (Microsoft, 2018). All NPOs have initiatives designed to facilitate access for under-served communities. These include waiving program fees, offering events and activities online, and travelling to remote areas to deliver programming.

Initiatives that seek to provide barrier-free access for girls in underserved communities are essential. The COVID-19 pandemic expedited many of the NPOs' plans to increase access through delivering parts of their programming online. This had a positive impact for some individuals, though lack of access to a stable internet connection remains a barrier for many. Ultimately, funding is required to sustain barrier-free initiatives, and securing funding is often the biggest challenge.



PROGRAM DESIGN

Fun, hands-on, exploratory approaches

All NPO representatives emphasised the hands-on and exploratory nature of their STEM-based activities and events. Rather than having instructors simply transmit STEM knowledge to participants, activities are designed to ensure participants are actively involved in the learning process. They are invited to explore, experiment and make mistakes. Adjectives and phrases used by representatives when discussing and describing their programming are encapsulated in the word cloud below (Figure 2).



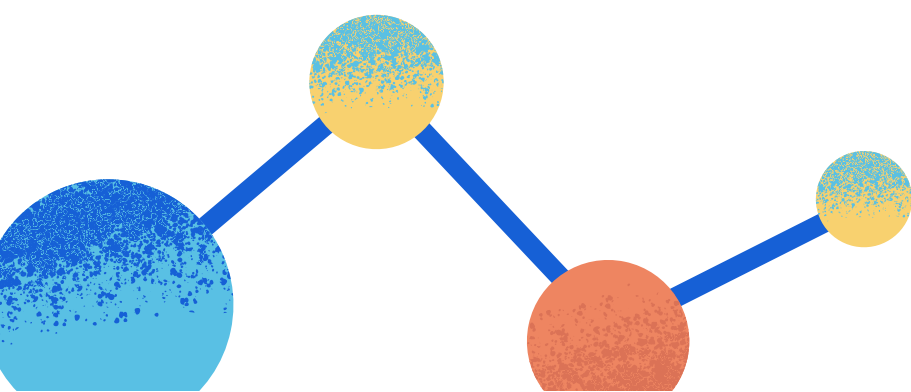
Figure 2 – Adjectives used by NPO representatives when describing their programming

There are countless studies evidencing that hands-on STEM learning can contribute to increases in students' interest and confidence in STEM (Aschbacher, Ing and Tsai, 2013; Essig et al., 2020; Yu, Chen and Chen, 2019). Internal evaluations undertaken by some NPOs also highlight the positive impact of hands-on, exploratory activities, with participants often citing this aspect as their favourite part of the programming. In addition to positively impacting participant enjoyment, some representatives mentioned further benefits. Namely, that this type of approach can spark interest in other areas and quell fears around making mistakes. If girls are encouraged to explore, problem solve and make mistakes, they are more likely to become comfortable with failure and embrace opportunities they might have otherwise forgone.

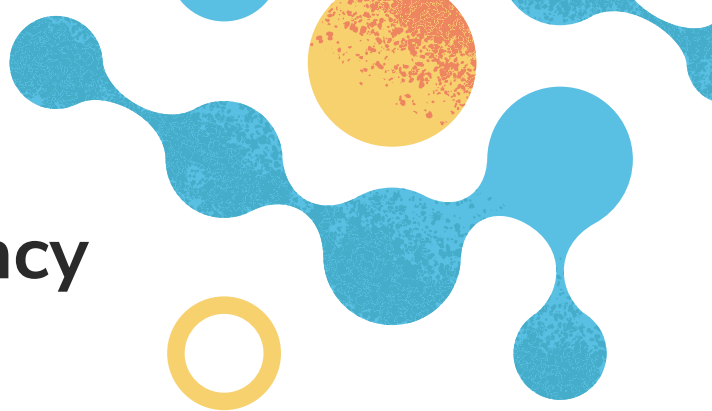
Although designing and delivering fun, hands-on activities is central to a lot of programming, some representatives pointed to the importance of creating multiple points of entry too. Participants come to events and activities with varying interests, different experiences, and different levels of knowledge and confidence. Therefore, ensuring there are opportunities for participants to engage in ways that are meaningful and appropriate for them is crucial. Such an approach might allow, for example, one participant to design a robot by putting pen to paper, and another to experiment by building with blocks and other materials.

A report by [Let's Talk Science](#) (2022) calls attention to the 2018 PISA results, which highlight how, in most education systems around the world, girls express greater fear of failure than boys. Let's Talk Science suggests that focussing on the process, not the end result, can not only help normalise failure, but can spur young people to be more innovative and creative.

It is important to note that although children might report science to be fun and state they enjoy hands-on exploration, this does not necessarily translate into pursuit of further engagement with STEM (Archer et al., 2010). If engagement beyond compulsory schooling is the goal, then delivering activities that are fun and hands-on should be part of a broader set of initiatives. However, even if enjoyment does not always lead children to pursue a STEM career, the transferable skills acquired through participating in exploratory activities are undeniably valuable. Learning to become comfortable with failure, working collaboratively, and building problem solving capabilities have far-reaching benefits.



Relatability and relevancy of the programming



Much of the NPOs' programming is designed with relatability and relevancy in mind. Many of the representatives I spoke with emphasised the importance of girls feeling that the content they are engaging with is somehow connected to their lives and local communities. This approach is in line with research showing that making STEM relevant to girls' personal experiences can positively impact their engagement (Gonsalves, Rahm and Carvalho, 2013; King and Pringle, 2019).

Some of the NPOs' programs focus specifically on supporting girls with designing and developing innovative technologies that could help solve community issues. A number of representatives said they often observe girls' engagement increasing when they can apply STEM knowledge to phenomena they themselves are experiencing, for example, extreme weather conditions or local environmental problems. Informal environments for science learning (non-school settings) can be beneficial in this regard – experiences in settings such as the home, museums, and nature centres can 'lead to further inquiry, enjoyment, and a sense that science learning can be personally relevant and rewarding' (National Research Council 2009: 11).

Girls Inc. of Northern Alberta's program, **Reaching SMART**, encourages girls to engage with local land and cultures through fostering meaningful connections with Indigenous communities. The program centres Indigenous teachings, which are supplemented with Western STEM knowledge and inquiry. With the aim of fostering sustainable and inclusive futures, the program is exemplary of how STEM-related activities can be relevant and contextually-specific.

Asking girls for their input and ideas for STEM curricular can help ensure programming feels relatable and relevant for them. If practitioners can ascertain what their participants find interesting, more relevant offerings can be delivered. Of course, this is not always possible, especially with larger programs. In these instances, creating multiple points of entry can help ensure multiple interests are catered for.

BEYOND GIRLS

Engagement with parents, caregivers and other adults

It is clear that culture, family and wider communities can play a significant role in encouraging and facilitating young people's engagement with STEM education and careers (Young, Young and Ford, 2019). Some of the NPOs' programming goes beyond focussing on providing opportunities for girls to engage, also inviting other adults to participate in fostering and furthering girls' interest in STEM.

The Ontario Science Centre's 2022-23 business plan states their commitment to increasing access to science and building everyone's science capital. The centre has many initiatives designed to support this aim. In 2020, the centre ran a '**Curiosity Café**' as part of their International Day of Women and Girls in Science celebration. Visitors were invited to the café to participate in informal discussions around gender issues in STEM. Provided with scenarios and discussion prompts, participants were able to discuss topics like gender stereotypes and assumptions in an informal and relaxed setting.

UBC Geering Up deliver **STEM information sessions for parents and guardians**. The sessions 'provide practical strategies that caretakers use to motivate their youth/children in STEM at home. After all, opportunities to learn can exist anywhere, and parents and guardians often have the biggest influence on children's lives' (Rima Pradhan, UBC Geering Up, 2022).

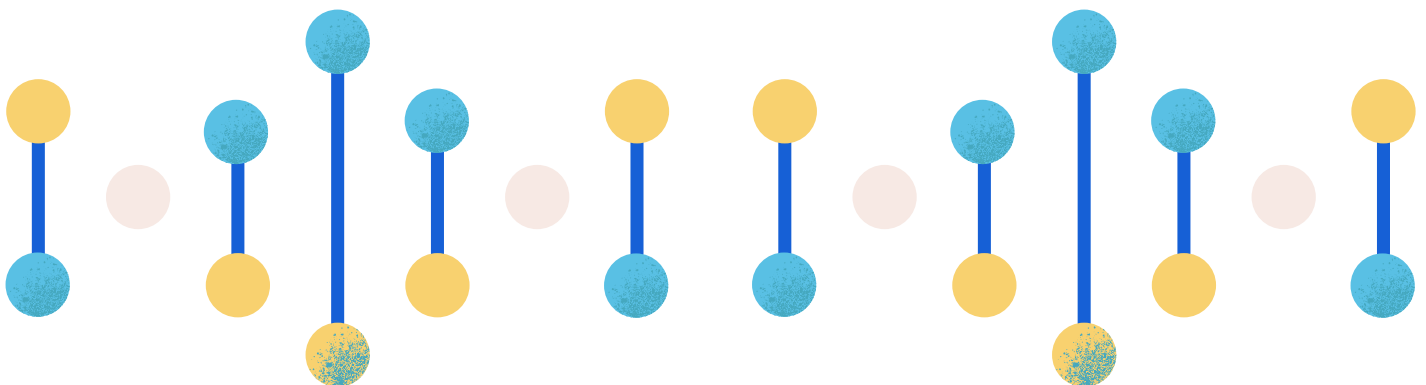
WWEST's **intergenerational workshops** 'extend understanding and increase comfort with STEM education and careers, for people of all ages' (WWEST, 2022).

These initiatives are prime examples of how NPOs are broadening the conversation on girls and women in STEM to involve girls' parents, caregivers, families and friends.

Although not focusing directly on girls, the Montréal Science Centre's use of **Gender-Based Analysis Plus (GBA Plus)** – an analytical process developed by the Government of Canada – to design their exhibition, Mini Mondo, provides a further example of practice that aims to include parents and caregivers in children's STEM education. Mini Mondo is an interactive world where children are invited to explore their environment through hands-on activities such as shopping in a bulk buy store, following animal tracks and learning how to grow vegetables. GBA Plus has numerous steps, beginning with identification of a target group. The centre chose to focus on immigrant families. They worked with a team of ethnographers to identify key issues for immigrant families and designed the exhibition with these issues in mind. One of their primary objectives was to provide a space where parents could be involved with their children's education, hence their inclusion of the six most common languages spoken in Montréal.

These types of initiatives highlight the collaborative effort needed to ameliorate gender disparities and inequities in STEM. In short, responsibility should not fall predominantly on the shoulders of girls

Initiatives such as these are invaluable. As stereotypes associating boys and men with STEM fields are often transmitted by teachers, parents, peers and media (Gunderson et al., 2012; Heldman et al., 2021; Keller, 2001; Leaper, Farkas, and Brown, 2012), facilitating opportunities for others to learn, question and reflect is essential. Furthermore, these types of initiatives highlight the collaborative effort needed to ameliorate gender disparities and inequities in STEM. In short, responsibility should not fall predominantly on the shoulders of girls.





Engagement in co-educational spaces

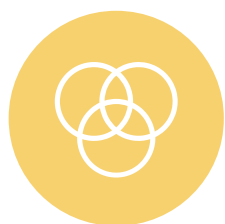
Girls-centred STEM programs have many benefits. Perhaps most notably, they can offer opportunities for girls to connect with other girls who share similar interests, passions and experiences. However, gender-inclusive programming that pays attention to girls' engagement also has benefits. Some of the NPO representatives I spoke with described strategies for encouraging girls' engagement in co-educational settings. These included having female instructors and presenters (an instantaneous way of signalling that women can and do engage with STEM); being mindful of which students are being called upon to ask and answer questions; and designing workshops that incorporate or speak to gendered issues in a thoughtful and engaging way.

The Ontario Science Centre's **Science School** invites grade 10 and 11 students to apply to spend a semester studying at the centre. Students take courses, work on a group project, and assist in delivering workshops and facilitating interactive activities with visitors. Part of the program involves student participation in a two-part equity workshop and engagement with A Question of Truth; an exhibit that invites visitors to explore how beliefs and biases can influence scientific research, and to test controversial theories related to race, gender and culture. Gender inequities and disparities in STEM are thus incorporated into the curriculum in a protracted way, providing all students – regardless of gender – the opportunity to reflect and engage with the issues in an environment that feels safe and supportive.

Gender-inclusive programming that takes girls' engagement seriously can increase boys' awareness of gender issues in STEM, and prompt important reflection on how they can make a difference

It is not the case that all programming should be girls-centred or gender-inclusive. There is space for both and value in having both. Gender-inclusive programming that takes girls' engagement seriously can increase boys' awareness of gender issues in STEM, and prompt important reflection on how they can make a difference. In addition to providing opportunities for girls to connect with other girls, girls-centred programming can provide more bespoke offerings that prioritise issues that affect girls and their engagement with STEM. Both types of programming are necessary.

RECOMMENDATIONS FOR NPOs



The category of girls is not homogenous, and **organisations must be aware of how intersecting axes of identity impact girls' engagement with STEM.**

Programming should be developed using an intersectional lens to ensure programming is as inclusive as possible. This is no easy feat, there is no 'silver bullet'. Organisations must remain committed to improving practices and consistently consider approaches from multiple perspectives.



Organisations need robust systems in place to evaluate the efficacy and impact of their programming. This will help determine which initiatives are most effective in achieving the intended outcomes. Evaluations should include longitudinal analysis where possible, and impact should be measured against clear objectives.



The development of digital or hybrid programming can support organisations who seek to broaden their reach and/or enhance their accessibility. However, digital expansion is not a panacea. Over-reliance on digital tools can exclude potential participants who do not have the necessary access to technology.



The main challenge organisations face in terms of facilitating access for the most marginalised, underrepresented individuals and groups, is insufficient funding. **Consistent sources of funding are required to develop sustainable, barrier-free, long-term programming.** This is crucial, as girls' extended engagement with STEM is proven to have a greater impact than engagement with one-off or isolated events.



It is clear that families, peers and wider communities can play a significant role in encouraging girls to explore STEM. Therefore, **more attention needs to be given to engaging girls' wider networks.**



Organisations should continue developing programming that is specific to their particular geographic, social, economic and cultural contexts.

Organisations would benefit from greater knowledge exchange with other organisations, but they must remain attentive to capitalising on opportunities, and tackling challenges, that are specific to their unique contexts.



Both girls-centred programming and gender-inclusive programming can positively impact girls' engagement with STEM. As they continue designing and developing programming, organisations should consider the benefits of both.



Cultivating a sense of belonging for girls is clearly important. However, it should not be assumed that this can only be achieved in girls-only spaces. For example, there is evidence to suggest that developing spaces where stereotypical beliefs are absent can also be effective.



Supporting girls to feel more confident is important for increasing girls' engagement with STEM, but interventions should not focus on this singular issue. Organisations should engage with girls to gain insight into their experiences, and/or consult research highlighting girls' perspectives.



Role models remain highly influential, especially when girls have opportunities to foster relationships with women in STEM. However, organisations must be careful not to eschew the realities of systemic and structural inequities/challenges when promoting individual success stories.

CONCLUSION

This knowledge synthesis highlights the need for continued commitment to engaging girls with STEM in Canada, and across the world. It draws attention to the extensive and varied work being undertaken by Canadian NPOs who are working to engage girls with STEM, illuminating a constellation of factors that tend to be considered when seeking to positively impact and enhance girls' engagement.

NPOs are integral to federal and provincial efforts to ameliorate gender disparities in STEM. It is hoped that the recommendations presented will support NPOs as they continue to develop their programming.

The recommendation that NPOs develop more robust systems to evaluate the efficacy and impact of their programming is of high importance. If a clear picture of what works can be ascertained, this will undoubtedly have a positive impact on initiatives in Canada and beyond.



LINKS AND RESOURCES

NPO Website Links

Girls Inc. of Upper Canada	https://girlsinc-uppercanada.org/
Girls Inc. of Northern Alberta	https://girlsincofnorthernalberta.org/
hEr VOLUTION	https://www.hervolution.org/
Mouvement Montréalais Les Filles & Le Code	https://concertationmtl.ca/mouvement-montrealais-les-filles-le-code/
Brilliant Labs	https://brilliantlabs.ca/
Montréal Science Centre	https://www.montrealsciencecentre.com/
Ontario Science Centre	https://www.ontariosciencecentre.ca/
Science World	https://www.scienceworld.ca/
Okanagan Public Library	https://orl.bc.ca/
Westcoast Women in Engineering, Science and Technology (WWEST)	https://wwest-cwse.ca/

WISEatlantic	https://www.wiseatlantic.ca/
Science ALIVE	https://sciencealive.ca/
UBC Geering Up Engineering Outreach	https://geeringup.apsc.ubc.ca/
Let's Talk Science	https://letstalkscience.ca/
Scientists in School	https://scientistsinschool.ca/
STEM Sorority	https://www.stemsorority.com/

Resources

Recommended by NPO representatives

- **Exhibit Designs for Girls' Engagement: A Guide to the EDGE Design Attributes**
 Developed by Toni Dancstep and Lisa Sindorf, the EDGE Design Attributes present nine of the most important attributes for engaging girls at STEM exhibits in museums. The document is available for download at:
www.exploratorium.edu/sites/default/files/pdfs/EDGE_GuideToDesignAttributes_v16.pdf.
- **Gender-based Analysis Plus (GBA Plus)**
 An analytical process developed by the Government of Canada to support gender- and diversity-sensitive approaches to work and initiatives. The process involves a number of steps that should be followed during design and development phases. Details of GBA Plus are available at: www.women-gender-equality.canada.ca/en/gender-based-analysis-plus/what-gender-based-analysis-plus.html.
- **Picture a Scientist**
 An award-winning 2020 documentary highlighting gender inequities in science. The documentary tells the story of three prominent, female scientists, calling attention to the discrimination and harassment they encountered. The official trailer can be found at: www.pictureascientist.com/.
- **IF/THEN Gender Equity Project**
 In partnership with the Association of Science and technology Centers (ASTC), the IF/THEN initiative aims to support science centers and museums to increase the representation of women in STEM across their exhibits and educational content. The initiative is built on the mantra: 'If we support a woman in STEM, then she can change the world'. Details can be found at: www.astc.org/ifthen/.

REFERENCES

- Archer, L. and DeWitt, J. 2015. 'Science Aspirations and Gender Identity: Lessons from the ASPIRES Project', In Henriksen, E., Dillon, J., Ryder, J. (eds.) *Understanding Student Participation and Choice in Science and Technology Education*. Dordrecht: Springer, pp. 89-102.
- Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., and Wong, B. 2013. 'Not Girly, Not Sexy, Not Glamorous': Primary School Girls' and Parents' Constructions of Science Aspirations', *Pedagogy, Culture and Society*, 21(1): 171-194. DOI: 10.1080/14681366.2012.748676.
- 2010. "'Doing" Science Versus "Being" a Scientist: Examining 10/11-Year-Old School Children's Constructions of Science Through the Lens of Identity', *Science Education*, 94(4): 617-639. DOI: 10.1002/sce.20399.
- Aschbacher, P.R., Ing, M., and Tsai, S.M. 2013. 'Boosting Student Interest in Science', *Phi Delta Kappan*, 95(2): 47-51. DOI: 10.1177/003172171309500211.
- Barth, J.M., Masters, S.L., and Parker, J.G. 2022. 'Gender Stereotypes and Belonging Across High School Girls' Social Groups: Beyond the STEM Classroom', *Social Psychology of Education*, 25(1): 275-292. DOI: 10.1007/s11218-021-09683-2.
- Bennett, D., Bawa, S. and Ananthram, S. 2021. 'Gendered Differences in Perceived Employability Among Higher Education Students in STEM and Non-STEM Disciplines', *Perspectives: Policy and Practice in Higher Education*, 25(3): 84-90. DOI: 10.1080/13603108.2020.1871090.
- Dasgupta, N. and Asgari, S. 2004. 'Seeing is Believing: Exposure to Counterstereotypic Women Leaders and its Effect on the Malleability of Automatic Gender Stereotyping', *Journal of Experimental Social Psychology*, 40(5): 642-658. DOI: 10.1016/j.jesp.2004.02.003.
- Essig, R.R., Elahi, B., Hunter, J.L., Mohammadpour, A., and O'Connor, K.W. 2020. 'Future Girls of STEM Summer Camp Pilot: Teaching Girls about Engineering and Leadership Through Hands-On Activities and Mentorship', *Journal of STEM Outreach*, 3(1): 1-9. DOI: 10.15695/jstem/v3i1.09.
- Fogg-Rogers, L. and Hobbs, L. 2019a. 'Catch 22 – Improving Visibility of Women in Science and Engineering For Both Recruitment and Retention', *JCOM: Journal of Science Communication*, 18(4): C05. DOI: 10.22323/2.18040305.
- 2019b. 'Women Like Me Executive Summary 2019'. Bristol, UK: Royal Academy of Engineering. Available at: <https://uwe-repository.worktribe.com/output/1970094/women-like-me-executive-summary-2019> (Accessed 13-12-2022).
- Gagnon, V. and Milan, A. 2020. 'Occupations of South Asian, Chinese and Black Women: Prevalence and Age Composition', *Labour Statistics: Research Papers*. 2020002. Available at: <https://www150.statcan.gc.ca/n1/en/pub/75-004-m/75-004-m2020002-eng.pdf?st=65qB917I> (Accessed 16-12-2022).
- Gibbs, K. 2014. 'Diversity in STEM: What It Is and Why It Matters'. *Scientific American*. Available at: <https://blogs.scientificamerican.com/voices/diversity-in-stem-what-it-is-and-why-it-matters/> (Accessed 06-04-2022).

- Gill, R. and Orgad, S. 2015. 'The Confidence Cult(ure)', *Australian Feminist Studies*, 30(86): 324-344. DOI: 10.1080/08164649.2016.1148001.
- Gonsalves, A.J., Rahm, J., and Carvalho, A. 2013. "'We Could Think of Things That Could Be Science': Girls Re-Figuring of Science in an Out-of-School-Time Club', *Journal of Research in Science Teaching*, 50(9): 1068-1097. DOI: 10.1002/tea.21105.
- González-Pérez S., de Cabo, R.M., and Sáinz M. 2020. 'Girls in STEM: Is It a Female Role-Model Thing?', *Frontiers in Psychology*, 11(2204): 1-21. DOI: 10.3389/fpsyg.2020.02204.
- Good, C., Rattan, A., and Dweck, C.S. 2012. 'Why Do Women Opt Out? Sense of Belonging and Women's Representation in Mathematics', *Journal of Personality and Social Psychology*, 102(4): 700-717. DOI: 10.1037/a0026659.
- Government of Canada. 2021. 'The Government of Canada and STEM'. Available at: <https://ised-isde.canada.ca/site/choose-science/en/government-canada-and-stem> (Accessed 21-04-2022).
- Gunderson, E.A., Ramirez, G., Levine, S.C., and Beilock, S.L. 2012. 'The Role of Parents and Teachers in the Development of Gender-Related Math Attitudes', *Sex Roles*, 66(3-4): 153-166. DOI: 10.1007/s11199-011-9996-2.
- Heaverlo, C., Cooper R., and Laanan, F.S. 2013. 'STEM Development: Predictors for 6th-12th Grade Girls' Interest and Confidence in Science and Math', *Journal of Women and Minorities in Science and Engineering*, 19(2): 121-142. DOI: 10.1615/JWomenMinorScienEng.2013006464.
- Heldman, C., Narayanan, S., Cooper, R., Conroy, M., Cooper-Jones, N., Brennan, C., Burrows, E., Campos, P., Christensen, S., Espinoza, C., Fava-Pastilha, M., Lórisdóttir, M., McTaggart, N., Perez, R., Phillips, H., Trinh, S., Virgo, J., Yoder, J., Baruah, S., Bose, D., Chiu, M.C., Flores, J., Greer, T., Guha, T., Hebbar, R., Kumar, N., Lahiri, R., Malandrakis, N., Martinez, V., Ramakrishna, A., Sharma, R., Singla, K., Tanlimco, C., and Young, A.. 2021. 'Closing the Stem Gender Gap: A Study of Gender and STEM Representations in UK Family Television. The Geena Davis Institute for Gender in Media'. Available at: <https://seejane.org/wp-content/uploads/closing-the-stem-gender-gap-uk-report.pdf> (Accessed 13-12-2022).
- Id-Deen, L. 2017. "'It will help me do better in mathematics": Building Trusting Relationships With Black Students', In Fernandes, A., Crespo, S. and Civil, M. (eds.) *Access and Equity: Promoting High-Quality Mathematics in Grades 6-8*. Reston, VA: NCTM, pp. 129-139.
- Keller, C. 2001. 'Effect of Teachers' Stereotyping on Students' Stereotyping of Mathematics as a Male Domain', *The Journal of Social Psychology*, 141(2): 165-173. DOI: 10.1080/00224540109600544.
- King, N.S. and Pringle, R.M. 2019. 'Black Girls Speak STEM: Counterstories of Informal and Formal Learning Experiences', *Journal of Research in Science Teaching*, 56(5): 539- 569. DOI: 10.1002/tea.21513.
- Leaper, C., Farkas, T., and Brown, C.S. 2012. 'Adolescent Girls' Experiences and Gender-Related Beliefs in Relation to Their Motivation in Math/Science and English', *Journal of Youth and Adolescence*, 41(3): 268-282. DOI: 10.1007/s10964-011-9693-z.
- Lewis, K.L., Stout, J.G., Finkelstein, N.D., Pollock, S.J., Miyake, A., Cohen, G.L., and Ito, T.A. 2017. 'Fitting in to Move Forward: Belonging, Gender, and Persistence in the Physical Sciences, Technology, Engineering, and Mathematics (pSTEM)', *Psychology of Women Quarterly*, 41(4): 420-436. DOI: 10.1177/0361684317720186.
- Let's Talk Science. 2022. 'Let's Talk Science Spotlight on Science Learning – Snapshot of a Decade'. Available at: <https://letstalkscience.ca/spotlight-on-science-learning-snapshot-a-decade> (Accessed 09-12-2022).
- Litzler, E., Samuelson, C.C., and Lorah, J.A. 2014. 'Breaking it Down: Engineering Student STEM Confidence at the Intersection of Race/Ethnicity and Gender', *Research in Higher Education*, 55(8): 810-832. DOI: 10.1007/s11162-014-9333-z.

- Maltese, A.V. and Tai, R.H. 2010. 'Eyeballs in the Fridge: Sources of Early Interest in Science', *International Journal of Science Education*, 32(5): 669-685. DOI: 10.1080/09500690902792385.
- Marzocchi A.S. 2016. 'The Development of Underrepresented Students' Sense of Belonging in the Mathematics Community Through Participation in College Outreach', *Journal of Women and Minorities in Science and Engineering*, 22(2): 119-138. DOI: 10.1615/JWomenMinorScienEng.2016013620.
- Master, A., Cheryan, S., and Meltzoff, A.N. 2016. 'Computing Whether She Belongs: Stereotypes Undermine Girls' Interest and Sense of Belonging in Computer Science', *Journal of Educational Psychology*, 108(3): 424-437. DOI: 10.1037/edu0000061.
- Master, A., Cheryan, S., Moscatelli, A., and Meltzoff, A.N. 2017. 'Programming Experience Promotes Higher STEM Motivation Among First-Grade Girls', *Journal of Experimental Child Psychology*, 160: 92-106. DOI: 10.1016/j.jecp.2017.03.013.
- Master, A. and Meltzoff, A.N. 2020. 'Cultural Stereotypes and Sense of Belonging Contribute to Gender Gaps in STEM', *International Journal of Gender, Science and Technology*, 12(1): 152-98. Available at: <https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE1UMWz> (Accessed 08-12-2022).
- Master, A., Meltzoff, A.N., and Cheryan, S. 2021. 'Gender Stereotypes About Interests Starts Early and Cause Gender Disparities in Computer Science and Engineering', *PNAS*, 118(48): 1-7. DOI: 10.1073/pnas.2100030118.
- Microsoft. 2018. 'Closing the STEM Gap: Why STEM Classes and Careers Still Lack Girls and What We Can Do About It'. Available at: <https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE1UMWz> (Accessed 14-12-2022).
- Microsoft. 2017. 'Why Europe's Girls Aren't Studying STEM'. Available at: https://news.microsoft.com/uploads/2017/03/ms_stem_whitepaper.pdf (Accessed 10-12-2022).
- Miller, D.I., Nolla, K.M., Eagly, A.H., and Uttal, D.H. 2018. 'The Development of Children's Gender-Science Stereotypes: A Meta-analysis of 5 Decades of U.S. Draw-A-Scientist Studies', *Children's Development*, 89(6): 1943-1955. DOI: 10.1111/cdev.13039.
- Moote, J., Archer, L., DeWitt, J., and Macleod, E. 2020. 'Comparing Students' Engineering and Science Aspirations From Age 10 to 16: Investigating the Role of Gender, Ethnicity, Cultural Capital, and Attitudinal Factors', *Journal of Engineering Education*, 109(1): 34-51. DOI: 10.1002/jee.20302.
- National Research Council. 2009. *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, DC: The National Academies Press. DOI: 10.17226/12190.
- Olsson M., and Martiny S.E. 2018. 'Does Exposure to Counterstereotypical Role Models Influence Girls' and Women's Gender Stereotypes and Career Choices? A Review of Social Psychological Research', *Frontiers in Psychology*, 9(2264): 1-15. DOI: 10.3389/fpsyg.2018.02264.
- Ontario Science Centre. 2020. Ontario Science Centre 2022-23 Business Plan. Available at: <https://www.ontariosciencecentre.ca/media/2888/2022-23-business-plan.pdf> (Accessed 19-12-2022).
- Orenstein, P. 2013. *Schoolgirls: Young Women, Self Esteem, and the Confidence Gap*. New York: Anchor.
- Organisation for Economic Co-operation and Development. 2019. 'Programme for International Student Assessment Results from PISA 2018'. Programme for International Student Assessment. Available at: https://www.oecd.org/pisa/publications/PISA2018_CN_CAN.pdf (Accessed 22-12-2022).
- Raabe, I.J., Boda, Z., and Stadtfeld, C. 2019. 'The Social Pipeline: How Friend Influence and Peer Exposure Widen the STEM Gender Gap', *Sociology of Education*, 92(2): 105-123. DOI: 10.1177/0038040718824095.

- Scientists in School. 2021. 'Our Journey: Propelling Canada's Young People to Bright Futures. 2020-2021 Annual Report'. Available at: <https://scientistsinschool.ca/impact/annual-reports/> (Accessed 01-12-2022).
- Statistics Canada. 2016. Census of Population for Canada. Available at: <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/index-eng.cfm> (Accessed 22-12-2022).
- Stoet, G. and Geary, D.C. 2018. 'The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education', *Psychological Science*, 29(4): 581–593. DOI: 10.1177/0956797617741719.
- Stout, J.G., Dasgupta, N., Hunsinger, M., and McManus, M.A. 2011. 'STEMing the Tide: Using Ingroup Experts to Inoculate Women's Self-Concept in Science, Technology, Engineering, and Mathematics (STEM)', *Journal of Personality and Social Psychology*, 100(2): 255–270. DOI: 10.1037/a0021385.
- Teo, T.W. 2022. 'Old Structures, Missing Systems: Why Does Gender Inequity in STEM Persist?' *The Forum Network*. Available at: <https://www.oecd-forum.org/posts/old-structures-missing-systems-why-does-gender-inequity-in-stem-persist> (Accessed 12-04-2022).
- Thoman, D.B., Sansone, C. Fraughton, T., and Pasupathi, M. 2012. 'How Students Socially Evaluate Interest: Peer Responsiveness Influences Evaluation and Maintenance of Interest', *Contemporary Educational Psychology*, 37(4): 254–265. DOI: 10.1016/j.cedpsych.2012.04.001.
- UNESCO. 2017. *Cracking the Code: Girls' and Women's Education in STEM*. Paris: UNESCO Publishing.
- Wall, K. 2019. 'Insights on Canadian Society: Persistence and Representation of Women in STEM Programs'. Ottawa, ON: Statistics Canada. Catalogue no. 75-006-X. Available at: <https://www150.statcan.gc.ca/n1/pub/75-006-x/2019001/article/00006-eng.htm> (Accessed 16-12-2022).
- Young, J.L, Young, J.R., and Ford, D.Y. 2019. 'Culturally Relevant STEM Out-of-School Time: A Rationale to Support Gifted Girls of Color', *Roeper Review*, 41(1): 8-19. DOI: 10.1080/02783193.2018.1553215.
- YPulse. 2018. 'The Confidence Collapse and Why it Matters for the Next Gen'. Available at: <https://static1.squarespace.com/static/588b93f6bf629a6bec7a3bd2/t/5ac39193562fa73cd8a07a89/1522766258986/The+Confidence+Code+for+Girls+x+Ypulse.pdf> (Accessed 12-12-2022).
- Yu, H-P., Chen, H-Y., and Chen, Y-L. 2019. 'The Hands-On STEM Curriculum Design Promoting Science Learning and Career Self-Efficacy for Gifted Girls'. In *Proceedings of the 2019 3rd International Conference on Education and Multimedia Technology (ICEMT 2019)*. New York: Association for Computing Machinery, pp. 225–228. DOI: 10.1145/3345120.3345135.

APPENDICES

Appendix I: NPO Bios

Brilliant Labs

Based in the Atlantic region, Brilliant Labs aims to foster innovation and a socially and environmentally responsible entrepreneurial spirit into classrooms and communities. Brilliant Labs seeks to provide educators and youth with opportunities to develop the necessary coding and digital skills required to create, innovate and inspire a future of sustainable development and growth throughout communities. Brilliant Labs is currently developing additional, girls-centred programming.

Girls Inc. of Northern Alberta

Girls Inc. of Northern Alberta serves communities across the Regional Municipality of Wood Buffalo and throughout Northern Alberta. In addition to delivering Operation SMART, this branch delivers a program called Reaching SMART. Reaching SMART seeks to harmonise western STEM inquiry-based learning and Indigenous land-based teachings to highlight to girls the meaningful connections that can help foster a sustainable future.

Girls Inc. of Upper Canada

Girls Inc. is an international charitable organisation that seeks to equip girls with skills to navigate through economic, gender, and social barriers. The Upper Canada branch of Girls Inc. serves communities in Leeds and Grenville, Ontario. One of Girls Inc.'s critical goals is to support girls' academic achievement. Their Operation SMART program focuses specifically on STEM, providing girls with hands-on, experiential opportunities to engage with STEM-related activities during workshops, events, and camps.

hEr VOLUTION

Girls Inc. is an international charitable organisation that seeks to equip girls with skills to navigate through economic, gender, and social barriers. The Upper Canada branch of Girls Inc. serves communities in Leeds and Grenville, Ontario. One of Girls Inc.'s critical goals is to support girls' academic achievement. Their Operation SMART program focuses specifically on STEM, providing girls with hands-on, experiential opportunities to engage with STEM-related activities during workshops, events, and camps.

Let's Talk Science

Let's Talk Science is a national organisation committed to preparing youth for evolving career and citizenship demands in a rapidly changing world. They provide programs and resources for educators that help them improve youth engagement in STEM, paying particular attention to the needs and interests of girls. Let's Talk Science also supports volunteers, the majority of which are postsecondary students, to build career-readiness skills by delivering and participating in programming.

Montréal Science Centre

The Montréal Science Centre holds an annual event for girls and STEM which aims to support and inspire girls' interest in STEM, and to showcase the diversity of opportunities available in STEM-related careers. The centre also has a number of initiatives designed to ensure all visitors feel welcome and that exhibitions are accessible for all.

Mouvement Montréalais Les Filles & Le Code

Mouvement Montréalais Les Filles & Le Code (MMFC) is part of Concertation Montréal, an organisation that works to develop Montréal area through consultation with socio-economic stakeholders and elected officials. MMFC supports youth to develop technological skills, and facilitates mentoring relationships between girls and women working in technological-related fields.

Okanagan Regional Library

Okanagan Regional Library offers STEAM programming (workshops and events) at many of their branches. Some of the libraries also have Makerspaces, which house equipment and tools for hands-on projects, digital media creation, and exploring and learning new technology. Families can also access virtual STEAM programming (newsletters and activities, online events and videos) and borrow STEAM-related equipment from the Library of Things.

Ontario Science Centre

The Ontario Science Centre is based in Toronto. The centre undertakes outreach work through its extensive education and public programming. One of the centre's strategic pillars is to make science accessible to as many people as possible, with the view to increasing individuals' science capital. The centre has a number of initiatives that are focussed specifically on gender inclusivity.

Science ALIVE

Affiliated with Simon Fraser University, Science ALIVE strives to engage youth in hands-on STEAM (Science, Technology, Engineering, Art and design, Mathematics) programs to build measurable skills and improve self-confidence. Science ALIVE aims to dispel stereotypes in the field of science and engineering and work towards achieving diversity and inclusion.

Scientists in School

Scientists in School is a national STEM education organisation that aims to support children and youth to be confident in STEM, build critical thinking skills, and heighten their interest in STEM careers through delivering hands-on, investigative workshops. Sparking curiosity and confidence in children so that they feel empowered to say, "I can be a scientist!" is at the core of every workshop, with careful consideration being given to encouraging girls' engagement.

Science World

Science World is a science centre in Vancouver. The centre's program, Girls and STEAM, includes an annual summit and other mentorship events throughout the year. The program aims to dispel myths about STEAM occupations and gives girls a welcoming space to engage in STEAM-based activities in order to increase their interest and confidence. It also highlights the local community and resources available to girls and women in STEAM.

STEM Sorority

Noticing that many girls found male-dominated STEM clubs at their school unapproachable, a group of high school students created STEM Sorority. With branches in five schools across Vancouver, STEM Sorority offers girls a comfortable and supportive environment to explore their passion for STEM, through delivering hands-on activity sessions. STEM Sorority also delivers information sessions with women working in STEM-related fields.

UBC Geering Up Engineering Outreach

Geering Up's mission is to provide accessible STEM education for all and inspire the next generation of critical scientific thinkers. Affiliated with the University of British Columbia, Geering Up is designed and facilitated by UBC students. UBC Geering Up serves youth across British Columbia with the mandate of bridging existing gaps that prevent equity-deserving student groups of all ages from accessing science, engineering, and technology education. They offer a range of girls*-only programs and endeavour to show program participants how fun, exciting, and useful engineering and science can be.

**The Geering Up team has an inclusive view of the words 'girl' and 'women' and use * to specifically and intentionally include cis and trans women, as well as genderqueer or non-binary people and other gender minorities.

Westcoast Women in Engineering, Science and Technology (WWEST)

WWEST is the NSERC Women in Science and Engineering Program for the British Columbia/Yukon Region. With an overall goal to support intersectionality and diversity, WWEST works to provide equitable and inclusive learning and working environments for underrepresented persons in science and engineering through outreach STEM programming events and school visits, collaborative efforts with partners and networks, research and action for change, and Intergenerational learning opportunities.

WISEatlantic

WISEatlantic is part of the NSERC Women in Science and Engineering Chair Program. Serving the Atlantic Region, WISEatlantic works to give girls access to role models through mentorship, workshops, camps and videos. WISEatlantic also supports and connects Atlantic Canadian female professionals in science and engineering fields through networking events and professional development workshops.



Appendix II: Guiding Questions

- Can you describe the work you do in relation to girls and STEM?
- Do you have staff members run your programs? Volunteers? Both? How many?
- Which programs have been most successful? Why?
- What are some challenges you face around girls and STEM programming?
- What type of feedback do you typically receive from girls and their parents/guardians?
- How do you evaluate the efficacy/impact of your work?
- How do you determine what audiences are most important to serve?
- Do you collaborate with any other organisations? If so, could you describe this work?
- What do you offer digitally / online? Are you looking to expand this work? How?
- What do you do to engage teachers and educators? Do you do any work with higher education institutions?
- How are your programs funded?
- What are your current and future aims/objectives?

