An Overview of Current After School - OST STEM Programs for Girls

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Abstract

Historically, there has been a gender gap within the STEM pipeline, resulting in the underrepresentation of women in STEM fields. Current efforts, both within and outside of educational institutions, have been developed to target girls' specific needs with the aim of supporting girls' interest and engagement in STEM. The following paper examines the social and cultural factors that perpetuate the gender gap in STEM. It also provides a review and critique of six existing Canadian Out of School Time (OST) STEM programs that focus on girls and the principles used in their development and implementation. Conclusions from this review suggest that OST programs, when developed using best practices, may play a crucial role in encouraging girls to pursue a STEM career. Four primary best practices include social and collaborative learning, topics related to girls' interests, development of STEM identity, and length of the program (for example, programs done over a longer period of time are generally more effective than programs completed over a shorter duration). Although the COVID-19 pandemic has caused some of these programs to migrate online, these four promising practices transcend face-to-face versus online boundaries. As a result, programs should continue to follow these pedagogical approaches to foster girls' interests in STEM.

Keywords: Gender inequality, out of school time programs, social learning, STEM education, STEM programming

INTRODUCTION

More than two decades into the 21st century, there is still gender inequality in male-dominated STEM (Science, Technology, Engineering, Mathematics) careers and degrees. Although the number of women with a university or college degree has increased, they are still underrepresented in STEM fields. Regional averages worldwide indicate that women's employment represents 29.3% in scientific research and development (UNESCO, 2019). Though women are underrepresented in STEM, this is even more pronounced when looking at women of colour or racialized women. According to the National Center for Education Statistics (2020) report, women of colour remain the least represented group in STEM majors, with degree recipients among Black women at 2.8%, Hispanic women at 4%, and Asian women at 4.1%.

Ferguson (2016) reported that more women in Canada hold postsecondary degrees (from universities and colleges) than ever before. The proportion of women with a university certificate or college degree increased from 15% to 35% between 1991 and 2015. As of the 2016 Census, 31.3% of women of colour have a university or college certificate, diploma, or degree compared to Canada's general women population (Statistics Canada, 2018).

Figure 1

Girl postsecondary enrolments in STEM and STEM subjects between 2010 and 2018

The number of women graduates in STEM-related fields continues to lag behind their male counterparts (Ferguson, 2016). Moreover, according to the report¹, the proportion of women enrolled in postsecondary STEM education has increased from 36.1% to 37.8% between 2010 and 2018 (Figure 1). In other words, slightly more than a third of girls choose to study STEM-related subjects in higher education, which means that girls are still the minority in STEM majors, especially in engineering, mathematics, and computer science fields. Moreover, there were differences in the distribution of women with STEM credentials; for example, over one-third of

¹ Statistics Canada. Table 37-10-0163-02 Proportion of male and female postsecondary enrolments, by International Standard Classification of Education, institution type, Classification of Instructional Programs, STEM and BHASE groupings, status of student in Canada and age group
DOI: <https://doi.org/10.25318/3710016301-eng>

STEM graduates had studied biology, not mathematics, computer science or engineering. Women who studied biological, chemical or physical sciences were less likely to work in STEM occupations than engineering graduates (Frank, 2019). Furthermore, over the last ten years, the proportion of women working in natural and applied sciences and related occupations was less than a quarter (21.8% in 2010 and 23.6% in 2019)². This pattern means women continue to be less likely to pursue a future in STEM-related jobs.

In light of these data, what could be the reason for this minimal increase in enrolment of girls and women in STEM fields over the past 20 years? There have been efforts within school systems to support teaching programs to close this gap and encourage and attract girls' attention to STEM-related programming. There are also numerous after school or Out of School Time (OST) STEM programs (hereafter referred to as OST programs) that aim to support girls' engagement in STEM-related careers.

An important factor impacting our methodology in undertaking this review was the advent of the Covid-19 pandemic. Particularly in the first quarter of 2020, school systems globally have undergone a drastic change due to COVID-19 disruptions. Schools were shuttered, and teachers were forced to implement full or partial distance learning to contain the COVID-19 outbreak. More than 60% of the student population has been affected globally (UNESCO, 2020), and this pandemic is also causing more gender equality issues in education (Global Education Monitoring Report Team, 2020). According to the Global Education Monitoring report (2020), globally, the adverse effects of COVID-19, such as the economic impact, may force over 11 million girls out of school, especially in low-income countries.

Moreover, based on the Ebola crisis data, the Malala Fund (2020) estimates that this number for girls could be 20 million in low- and lower-middle-income countries after the pandemic has passed. Another survey result shows that three in five teachers across Asia, Africa and Latin America stated that due to COVID-19, girls (59%) and poorer children (62%) would drop out of school in the long term (ActionAid, 2020). The World Bank report stated that in low and lower-middle countries, for children between 12 to 17, girls are more at risk of not returning to school than boys. For example, some girls never returned to school during the Ebola pandemic because of early pregnancy or marriage (Azevedo et al., 2020). Furthermore, according to the All Pakistan Private Schools Federation, when schools were reopened, half of the students did not return to school, and 60% were girls (Ali, 2020). Since COVID-19 poses challenges for gender inequalities, it is more important than ever to support girls' and women's future education careers (Global Education Monitoring Report Team, 2020).

Not only have school systems been affected, but OST programs have also updated their content because of the unprecedented COVID-19 outbreak and the subsequent move to online learning. This shift into online spaces may further the divide between marginalized students and STEM due a persistent gap in access to technology, otherwise known as the digital divide. The digital divide most impacts marginalized communities, such as individuals living in low socioeconomic areas. Marginalized students who may rely on public spaces with free access to wifi or computers have limited access as many of these spaces have been closed and/or open

² Statistics Canada. Table 14-10-0335-02 Proportion of women and men employed in occupations, annual
DOI: <https://doi.org/10.25318/1410033501-eng>

inconsistently during the pandemic (Roth, 2020). These compounding factors suggest that it is significant to identify and promote the best practices in OST STEM programs to ensure that the pandemic does not slow the progress made in recent years on girls' engagement in STEM-related careers, especially girls in marginalized communities who may not have access to online OST programs. This review aims to evaluate the current literature surrounding OST STEM programs and the common factors that support increased engagement, especially girls' engagement. This review paper summarizes and critiques six different OST programs focused on girls offered in Canada and considers whether they reflect identified best practices or not, based on common themes that would emerge from the literature review. This paper will also explore the impact that the COVID-19 outbreak has had on these OST programs.

LITERATURE REVIEW

At the outset of this review, we note that gender is socially constructed, and essentializing girls and women as all learning, in the same way, is highly problematic. We acknowledge that gender is performed in many ways, based on background, experiences, and lived realities (Butler, 1988). Awareness of intersectionality should guide the developers of programs that target specific groups, such as Black Boys Code³, a Canadian organization that aims to inspire “young Black men to take control of their future and become tomorrow’s digital creators and technological innovators” (blackboyscode.ca). Access to quality OST programming is not just about gender but also related to class, race and other interdependent systems of discrimination or disadvantage.

Many out-of-school STEM programs use an integrative approach to engage students academically, intellectually, socially, and emotionally. These features are key to developing positive outcomes for youth (National Research Council, 2015). Moreover, according to the meta-analysis study of Young et al. (2017), OST STEM programs with both academic and social elements are more effective than programs that are only academically focused. They stated that adding a social component might increase students' STEM interest (Young et al., 2017).

Good practice in OST STEM programs involves some features, such as providing girls with a social and collaborative learning environment. Although socialization and collaboration provide girls and boys with enhanced learning environments, Watermeyer (2012) emphasized that adding social components among homogenous study groups may contribute to girls' motivation and engagement in OST programs. Their research explored the effects of the Discover! program, a Saturday science activity club exclusively open to young girls. Watermeyer (2012) conducted this research to challenge the normalized invisibility of gender inequity within the STEM classroom. The Discover! program used experiential learning to facilitate tangible and meaningful STEM experiences. This study found that the same-sex social environment is conducive to creating supportive friendships and producing an environment where the participants felt secure. Not only that, but participants noted that having a girl-only environment allowed them to have a “safe space” in which they could speak freely without worry that boys would take over the conversation and dialogue. The ethnographic observations also showed that participants became more familiar with each other and began to mix as the sessions progressed. Watermeyer's (2012) study contributes to

³ <https://blackboyscode.ca/>

understanding how social learning among girls can be a significant moderator for the enjoyment of science.

A study conducted by González-Pérez et al. (2020) used the theory of role congruity, which holds that social and soft skills are more congruent with women's goals (such as working with others or helping others people). In other words, they argue, women are more likely to endorse these goals that require communication and social abilities. Therefore, they used these skills, which are more congruent with women's roles. In their study, sessions with women role models were designed, and first-hand information was provided to girls about necessary non-stereotypical skills such as social and communication skills to pursue a STEM career. Their study showed that when girls perceived that STEM professions and activities require teamwork, communication, and social skills, their desire to pursue STEM careers was positively affected (González-Pérez et al., 2020). Therefore, afterschool and OST programs with social components might be more effective in engaging and encouraging girls in STEM fields.

According to the National Research Council (2015) report, OST programs should provide students with first-hand experience relevant to their experiences and aspirations to connect STEM with other settings to make it more meaningful for them. Moreover, another study (Mosatche et al., 2013) indicated that it is important for OST programs to provide hands-on and interdisciplinary projects relevant to girls' lives and real-world problems such as recycling projects. This was also reported in Margolis et al. (1999). The authors noted that women pursuing the field of computer science noted that it was very important that their work tangibly benefit others and society. Like all students, girls might find more appealing interactive activities than school-like activities. According to the analysis of another study (He, 2018), some girls stated that textbook-based teaching strategies have a negative impact on their scientific interests. They also stated that increasing practical applications could be more effective (He, 2018). Students, especially girls, are interested in activities that enable them to explore STEM careers and field trips to heighten their interest in STEM-related subjects (Mosatche et al., 2013). Another study (Blotnick et al., 2018) stated that to increase students' interest in STEM, an authentic learning environment should be created. These learning environments could provide collaborative learning, problem-solving, and the application of inquiry-based scientific knowledge with children while engaging in STEM subjects (Blotnick et al., 2018).

Several studies have focused on programs that incorporate 'typical' girls' interests into their STEM programming to increase the accessibility of STEM entry points. One such program is Fashion FUNdamentals (FF), featured in Ogle et al. (2017), which utilized fashion as an alternative approach to traditional STEM education. FF is a free-of-charge two-week summer program and completed on the university campus. The authors used this program to examine whether or not a typical middle school girl's interest, like fashion, could act as a catalyst for STEM interest. Leaving aside the stereotypical assumption that all middle school girls like fashion, in this longitudinal study, the authors measured girls' math and science knowledge using scales developed by the researchers. Although upon completion, the researchers noted that FF had positive influences on participants' self-efficacy in math and science, the students' knowledge scores in math pre- and post-assessments did not change. However, focus group data revealed that some girls' science knowledge increased. Moreover, participants' post-self-efficacy in science positively related to their interest in STEM. Therefore, providing girls with more personalized activities like this might help them feel more confident and positive about STEM fields.

A STEM identity can be defined as "a young person coming to see both her current and possible future selves in STEM" (Kang et al., 2019, p. 420). In general, it might be challenging for all students to identify themselves with STEM subjects because of having little or no personal contact with STEM professionals. However, it is more significant for girls to be exposed to inspiring and encouraging women role models in the learning environment to engage them in STEM fields (González-Pérez et al., 2020; Wajngurt & Sloan, 2019). González-Pérez et al. (2020) found that a friendly and warm atmosphere created by successful women role models in STEM fields positively contributed to girls' expectations of success in STEM careers. These role models might also prevent the perpetuation of gender stereotypes about STEM competency. Wajngurt and Sloan (2019) also found that if girls have limited personal relationships with their peers and STEM professionals, they might not develop STEM identity. Exposing girls to role models with similar backgrounds can encourage girls to follow in their steps in a STEM career (Mosatche et al., 2013).

Moreover, career awareness plays a significant role in whether young people choose a future career in STEM fields (Compeau, 2016). Some studies of STEM careers and media representations demonstrated that boys "wishfully" identify with male scientists while girls identify with female scientists (Steinke et al., 2012). However, Whitelegg and colleagues (2008) found that in fiction, cartoons, and non-fiction shows concerning science, white male scientists (following the authors' terminology) are largely overrepresented. Boys, then, have more opportunities to build STEM identity and wishfully identify through exposure to male scientists in media (Steinke et al., 2012). Whitelegg and colleagues (2008) further revealed that 73% of "draw-a-scientist" representations made by children were male. 13% were female depictions drawn by girls. Though some may believe that media and stereotypes have no bearing on the course of human action, Cheryan et al. (2013) conducted a study that revealed how media representations could act as a barrier to STEM and significantly influence individuals' identities. Through a series of interviews and surveys with college students, the authors concluded that stereotypes limit girls' interest in STEM, as the strong associations with males (following the terminology of Cheryan et al., 2011) inhibit the ability to see STEM as a realistic option for them.

Moreover, when considering a postsecondary path to pursue, students often compare themselves to those in the field and whether they would succeed in the environment. An earlier study (Cheryan et al., 2011) demonstrated that undergraduate women were less likely to be interested in taking computer science if exposed to a computer science classroom that contained stereotypical male objects and decorations, such as video games, Star Trek posters, than those exposed to a classroom which did not contain these objects. These stereotypical portrayals and media representations have the power to influence how people perceive the world as they establish norms and barriers. These barriers limit STEM as a perceived option for girls, perpetuating the misconception that males are simply better suited to STEM. This situation results in a stereotype and the inability to create a lasting STEM identity for girls.

Broadley (2015) identified collaborative learning as a way to increase entrance pathways into STEM for girls, particularly in out-of-school settings. Using Eccles' expectancy-value model of achievement-related choices as a framework, the author reviewed and analyzed entrenched gender pathways in STEM. The expectancy-value model posits that girls' learning led to the conclusion that girls must have extended opportunities for experiencing STEM outside of schools with women role models. Broadley categorized role models as a fundamental rather than a suggestion when building STEM programs. Pairing students with role models who are both enthusiastic and

successful in STEM can help combat the lack of perceived diversity in the field. According to the author, women mentors and role models may also help young girls see that STEM is heavily linked to helping others and provides great benefit to society by building innovative technologies and medicines - a characteristic that girls tend to value in future careers. Broadley (2015) mentioned that role models should be relatable and engaging to promote interest and help girls build their STEM identity by demonstrating the merits of STEM and its potential as a viable career choice.

The length of a STEM program has important implications for a STEM program's effectiveness and its impact on girls' participation. The earlier and longer an OST STEM program or intervention is introduced, the better. From a young age, girls and boys are ushered onto different pathways that determine the ease and likelihood of pursuing science-based careers and interests. If an intervention is introduced early, these stereotypes will be less ingrained into the young generation. Adams et al.'s (2014) study focused on the long-term impacts on girls in a multi-year OST STEM program. The authors found that long-term commitments to OST programs are a key component of developing sustained skills and self-efficacy to pursue a science career. The length of an OST program likely bolsters the process of identity building, as students become more comfortable with STEM as a facet of their lives - weaving it into their identities. It is reasonable to conclude that this multi-year program was beneficial to developing a long-term STEM identity and propelling the girls' interest in pursuing STEM in postsecondary education. Four key themes emerged from the interviews: sense of belonging, broad exposure to STEM topics and careers, building a collective identity and moving from museum to college. The authors concluded that long-term participation in OST programs significantly influences participants' engagement in STEM and raises the likelihood of participating in a STEM career (Adams et al., 2014).

Further supporting this idea is a doctoral dissertation by Cupp (2015), which examined the influence of the length of engagement in OST STEM programs on girls' engagement, achievement, and confidence in STEM within a school setting. This dissertation highlights valuable quantitative data of participating girls' interests, engagement, achievement, and confidence compared to boys' participation. Moreover, this study evaluates the effectiveness of multiple-term STEM programs compared to a single term. The findings of this study support the notion that an effective afterschool STEM program relies on multiple terms of engagement (participation in more than one session of the program). Multiple terms of engagement allow participants to foster a new interest in a topic, which reflects how they view STEM during the school day.

Similarly, Allen et al. (2019) showed that when students joined OST programs for four weeks or more, participants' engagement in STEM careers increased. According to additional research (German et al., 2017), girls' loss of STEM interest can start as early as the elementary level; therefore, it is essential to introduce girls to appealing STEM content before the middle school years and support their engagement throughout their education journey. Similarly, Wajngurt & Sloan (2019) stressed the early influence of STEM education on students, especially girls' desire to pursue STEM fields before internalizing gender stereotypes. The more girls participate in STEM-related activities, the more they become willing to engage in STEM careers (Mosatche et al., 2013). Therefore, more extended OST STEM programs could be useful to ignite girls' interest in STEM.

METHODS

This review targeted the existing literature on OST STEM programs and the common factors that support increased engagement, specifically girls' engagement. The research articles included in this review were compiled using Ontario Tech University's online library and searches of other articles' citations. The search used multiple terms, including combinations of "OST programs", "out of school programs", "science programs", "STEM programs", "girls", "gender gap", and "STEM education". The research articles selected were published and peer-reviewed to ensure high-quality information. After reviewing numerous papers, some were used for the determination of the emerged themes.

There are many OST programs, therefore, search engines and some university websites were used to evaluate these programs in terms of the themes that emerged. For this review, six OST programs, which were open to Canadians, were chosen from results that are ranked higher on the search engine result pages by using some specific keywords such as "after school programs", "STEM/STEAM", "STEM camp", and "girl". In order to narrow the scope of the paper, the number of the OST programs was limited to six. These OST programs' websites were analyzed between December 2020 and February 2021, and their activities for girls and content were also evaluated in terms of the impact of COVID-19 on the programs.

RESULTS

Based on the studies examined in the literature review, specific guidelines surrounding girls and STEM engagement in OST programs do not appear to exist currently. There are, however, some general themes on best practices. Several studies suggested some useful strategies to create learning environments to engage students, especially girls, in OST programs. For example, Microsoft suggests some categories such as providing women role models, hands-on activities and encouragement, generating excitement, and encouraging a "growth mindset" to close the gender gap (Microsoft, 2021, Inspire girls in STEM).

Since many OST STEM programs use different approaches to increase interest and participation in subject areas, some general themes could be used to determine the best practices. The common themes that have emerged in the literature are:

- social and collaborative learning,
- girls' interests,
- STEM identity, and
- the length of the program and early start.

Examples of Selected OST STEM Programs

In this review of existing OST programs that target girls' participation in STEM activities, we sought to discover which principles they used in developing their programming and how effective these strategies might be, based on evidence-based practices. We also explored what gender-based assumptions were used as a foundation to build the programs upon. For example, all

of the programming targeting girls and women in STEM clearly believe that same gender programming is beneficial, but on what do they base these assumptions?

1. Girls Who Code:

Girls Who Code⁴ is one of the non-profit organizations that aims to close the gender gap in computer science. It has different subprograms such as clubs, summer immersion programs and College Loops in the US, Canada, United Kingdom, and India. Their Afterschool Clubs⁵ program provides an atmosphere for students who identify as girls or non-binary to work as a team with their supportive peers and build community while working on interactive activities. Clubs also provide an opportunity for learners who are 3rd-5th and 6th-12th graders to solve real-world problems while working on their projects. The Summer Immersion Program⁶ is an experiential summer program for both girls and non-binary students. This 2-week program aims to prepare students in grades 10-12 for STEM careers. Before COVID-19, it usually took place within a university setting; however, in 2020-21, the program became virtual. With the help of this no-cost program, while students are learning computer science, they can create networks and participate in interactive activities. The College Loops⁷ program aims to create a community at a university level for college-age students who identify as girls regardless of assignment at birth by connecting and building relationships with field experts. In this way, they form groups to support and motivate one another and to achieve their academic goals. This free-of-charge program might also be important to prevent girls from leaving their STEM careers during the early years of their postsecondary education. Girls Who Code stresses the importance of building a "Sisterhood" to motivate and encourage one another. This term can help create a social community where learning takes place.

The programs offered by Girls Who Code provide participants with women role models among their peers and mentors. For example, Clubs and Summer Immersion Programs are places where STEM professionals can inspire girls. By participating in College Loops, young women are exposed to peer role models successful in STEM subjects. In this way, they can develop positive beliefs regarding women's abilities in STEM fields and change their beliefs about girls' negative stereotypes about STEM. Girls Who Code programs also address girls from 3rd grade to postsecondary levels. The organization aims to encourage and assist girls from early elementary to undergraduate levels by providing strong role models to develop and nurture STEM identity.

2. STEM Camp:

STEM Camp⁸ aims to encourage and motivate young Canadians by providing hands-on activities and projects related to STEM fields. This program tries to trigger children's curiosity through enjoyable and appealing learning activities by promoting learning and experimentation. They also declare that children can boost their confidence and success by solving challenging daily problems, and they provide an atmosphere for children to make new friends and collaborate in a world of STEM. STEM Camps are for both boys and girls 5 -13, and the participants need to pay

⁴ <https://girlswhocode.com/>

⁵ <https://girlswhocode.com/programs/clubs-program>

⁶ <https://girlswhocode.com/programs/summer-immersion-program>

⁷ <https://girlswhocode.com/programs/college-loops>

⁸ <https://stemcamp.ca/>

the registration fee. Children can play with their peers during the camp program and learn from the instructor who has a STEM-related background.

Before COVID-19, their camp programs had different weekly themes and activities for children, such as Star Wars, Minecraft, Superheroes, or Transformers for both the previous summer and winter camps. The idea behind choosing these themes for activities is based on the passion of STEM Camp regarding women in STEM. They stated this on their website: "STEM Camp does not subscribe to the theory that there are girl activities or boy activities. We further believe that activities are gender-neutral and that many girls will absolutely love perceived "boys" activities and vice versa. However, we also recognize that parents may need some activity examples when discussing STEM Camp with young girls to help combat the peer pressure that some young girls feel surrounding the stereotype of science and engineering being "boy" subjects." (STEM Camp, 2021, Girls in STEM section).

Moreover, STEM Camp has more than 50 locations in Ontario. Their education development team consists of women, and most of their camp staff inspire young girls in camp programs. They also stated that the proportion of girls in camp is increasing each year, which helps to close the gap in gender disparity.

In order to keep camps during the COVID-19 break, STEM Camp has started virtual sessions for their camp program. For example, the recent winter camp provides children with two different camp concepts (Minecraft and Scratch). For summer 2021, they have themes such as Star Wars, Harry Potter, Minecraft and Superheroes. Moreover, depending on the current impact of the COVID-19 pandemic, STEM Camp has alternative plans for in-person camps. These future camps commit fun, exciting and engaging hands-on activities for boys and girls while their curiosity and interest in STEM will be boosted.

3. The Ontario Network of Women in Engineering:

The Ontario Network of Women in Engineering⁹ (ONWiE) is a network between schools and universities in Ontario formed in 2005. This network aims to create a bridge between current women professionals in engineering and young girls to support and motivate youth to participate in engineering. It has subprograms such as Go ENG Girl¹⁰, Go CODE Girl¹¹, and Badge Day¹², which are free to attend.

Go ENG Girl is a platform where girls in grades 7-10 can learn more about engineering careers through hands-on activities and exhibits and work in teams to design a project. In addition, professionals from the STEM industry and college students share their experiences and stories with the participants as role models. Students can participate in one of these programs from October to December each year by selecting a hosting university.

⁹ <http://www.onwie.ca/>

¹⁰ <http://www.onwie.ca/programs/go-eng-girl/>

¹¹ <http://www.onwie.ca/programs/go-code-girl/>

¹² <http://www.onwie.ca/programs/badge-day/>

Go CODE Girl program's target is 7th to 10th graders, and it helps students explore various career opportunities in STEM-related fields. Students who join this event get the chance to meet professionals and experts who are computing and software engineers and peers with similar interests. Moreover, they can participate in hands-on activities by working in groups. It takes place from January to March during the year.

Badge Day is an organization for Girl Guides¹³ whose ages range from 5 to 14. These girls are invited to join workshops and hands-on activities with their troops at host universities. On this day, Sparks, Brownies, Girl Guides, and Pathfinders can find the opportunity to meet inspiring role models who have STEM careers. The universities generally run a Badge Day between January and July.

Because of the COVID-19 pandemic, most universities cancelled these events in 2020 or provided virtual events for the participants. Some of the events provided hands-on activities by shipping all the related materials in advance. Some events also build connections between role models by having guest speakers, such as academics and professionals from STEM fields. However, some of the universities' links do not provide detailed explanations or need updates related to COVID-19 cancellations.

4. Canada Learning Code:

Canada Learning Code¹⁴ works for "all people in Canada - particularly women-identified, transgender and beyond binary individuals; racialized people- have access to the knowledge they need to prosper in our digital world" (Canada Learning Code, 2021, About Us). Canada Learning Code offers various subprograms for specific communities, both in-person and online. This organization provides participants with hands-on activities and also collaborative and interactive learning opportunities. Canada Learning Code provides various subprograms such as Girls Learning Code, Ladies Learning Code or Teachers Learning Code to teach how to code. Because of COVID-19, there are currently no in-person events, and they currently provide several no-cost online workshops due to the COVID-19 outbreak.

The Kids Learning Code and Girls Learning Code programs are designed for children between 3 to 12 to encourage them to create with technology with the help of workshops, camps, and tech days. These programs provide hands-on activities, camps and local meetups for children to learn about coding by experiencing several ways. The programs provide learning environments where children can code games or create websites. Moreover, children are supported to become creators rather than just being consumers of the world of technology by their lead instructors and industry mentors. Depending on the existing impact of COVID-19, these subprograms are provided to participants virtually.

¹³ <https://www.girlguides.ca/web/GGC/>

¹⁴ <https://www.canadalearningcode.ca/>

5. The Cube School:

The Cube School¹⁵ provides OST and camps for both children and teens. They focus on different subjects, such as coding, design and some related topics to support improvement in STEAM (Science, Technology, Engineering, Arts and Mathematics) fields. Through hands-on activities and project-based learning, they aim to expose both children and teens to a learning environment to design and discover technology. Their programs have been affected by the COVID-19 disruption, and they have started to provide virtual sessions for their users. This organization offers various programs such as Virtual Classes for Kids¹⁶ and Teens¹⁷, Virtual Camps¹⁸, and PA Days¹⁹. The programs require registration fees, and the prices vary according to the content.

Virtual Classes for Kids present classes for grades 1 to 6 and Virtual Classes for Teens is designed for 7th graders and up. With small classes and live classroom environments, the instructors aim to reach each student to promote their achievement. The virtual classes vary from programming to robotics to electronic programs to 3D modelling. They can also learn specific programs such as Lego WeDo, Scratch, Minecraft, Photoshop, and Python. These programs might offer creative and collaborative activities and exploration-based projects to create more interactive learning environments. Some programs support participants' investigation skills; others provide opportunities to discover real-life projects with a hands-on approach. The lesson number of classes is changing from 5 to 12 for various programs.

Virtual Camps are provided for children and teens during 2020-2021. They offer different program content for different age groups, such as coding or game designing in multiplayer platforms. The camp program also provides teens with 3D modelling content. On PA Days, they provide children with a valuable learning experience by focusing on STEAM-related topics and enjoyable activities. In addition, they provide some equipment kits for pickup and drop-off in Toronto.

6. The STEAM Project:

The STEAM Project²⁰ aims to provide youth with a learning environment to gain the skills to be future innovation enablers. They arrange courses, camps and events to engage youth in STEM areas by supporting imagination and creativity. The instructors and counsellors with STEAM backgrounds present fun and hands-on STEAM activities with low- and high-tech tools. By providing real-life problems, the team encourages children to create solutions that require skills from real-life and STEAM-related subjects. In this way, they also try to boost children's self-confidence in STEM-related areas and present them with many STEAM professional opportunities. Participation in course and camp programs requires registration fees, and the prices vary according to the content. For their in-person activities, they provide different locations in Ontario, Richmond Hill.

¹⁵ <https://thecubeschool.ca>

¹⁶ <https://thecubeschool.ca/virtual-classes-for-kids>

¹⁷ <https://thecubeschool.ca/virtual-classes-for-teens>

¹⁸ <https://thecubeschool.ca/stem-camps>

¹⁹ <https://thecubeschool.ca/technology-pa-days>

²⁰ <https://www.thesteamproject.ca/>

The COVID-19 pandemic has also changed the content of the STEAM Project. Due to the limitations, they decreased the class size for in-person activities and postponed some of them or transitioned to online versions.

DISCUSSION

This review provides more detailed information about some of the OST programs in Canada, especially in Ontario. These programs provide engaging activities for kids and teens, but some, such as Girls Who Code, ONWiE, and Canada Learning Code, offer subprograms particularly for girls. In general, these programs share common visions like inspiring children, especially in STEM fields. From this perspective, STEM Camp and The Cube School highlight learning while having fun; however, Girls Who Code and ONWiE emphasize the importance of supporting girls in STEM fields and closing the gender gap. The STEM Camp also states that activities are gender-neutral, and children can like and engage in stereotypical opposite-gender activities.

Through the COVID-19 pandemic, many things have changed in terms of educational settings, and these changes have brought both opportunities and constraints. Since most of the courses and classes at different levels transitioned to virtual learning, this situation provided significant benefits such as accessibility and flexibility. However, this pandemic has inhibited access to resources for those students with limited internet access. Privileged students already enjoyed access to OST programming, an online option during a pandemic offers increased flexibility. For example, children from middle to high-income families were able to have personal computers and internet access. In addition, these children had the opportunity to choose the best options among offered OST virtual programs that suit their schedule or participate in OST STEM programs in different countries. However, for those with more limited access, the pandemic has further disadvantaged them and may negatively impact the developments achieved over the years in education, especially girls' education. In addition, most of the OST programs provided great options for children from low-income families before the COVID-19; therefore, the pandemic may undermine OST STEM programs' contributions.

The number of women in STEM-related occupations and girls' enrolment in STEM subjects is still not enough, and the COVID-19 disruption may not change this proportion for the better. However, the school closures and the changes in delivery methods may impact girls' engagement in STEM subjects. As stated before, schools are learning environments where girls can find interactive and collaborative learning opportunities with hands-on and experimental activities. Moreover, they could interact with their peers, STEM role models and mentors effortlessly in schools. Like school systems, OST STEM programs that play a crucial role in girls' engagement in STEM were also affected by the outbreak of COVID-19. Most of the OST programs had to transition from in-person environments to online platforms.

This paper analyzed several OST STEM programs in terms of themes that are the indicators of best practices. Moreover, the impact of COVID-19 pandemic on current practices has also been observed. These OST STEM programs were evaluated under four common themes, and the effects of the outbreak of COVID-19 were compared. The following sections will give a closer examination of some of these programs under common themes.

Social and Collaborative Learning

Some researchers (González-Pérez et al., 2020; Watermeyer, 2012) emphasized that activities requiring teamwork, communication, socialization and collaboration could contribute to children's and especially girls' engagement in STEM fields. That is why programs with these social components could reflect best practices for children. According to the analysis, before the COVID-19 outbreak, most of these programs provided social and collaborative learning components to support their participants' engagement in STEM subjects. Programs such as Girls Who Code use the term "Sisterhood" to underscore the influence of social connection among members. Especially with their clubs and summer immersion programs, this organization tries to protect girls' social and supportive dynamic before and after the pandemic by building this community.

Similarly, Go ENG and CODE Girl programs organized by ONWiE provide communities where the girls are the majority. As Watermeyer (2012) mentioned, these kinds of homogenous gender group atmospheres could meet girls' needs for a safe learning environment where they can speak freely without boys' intervention. In this way, girls might have OST STEM programs more tailored to their specific needs. Furthermore, providing girls with the opportunity to make connections and develop bonds with other girls is important for social growth and enjoyment. It ensures adequate room for girls to ask questions and participate in meaningful conversations and dialogue surrounding STEM topics.

Though social and collaborative learning opportunities play a key role in supporting girls' engagement in STEM OST programs, this does not indicate that only girls depend on and benefit from social and collaborative learning. Socio-constructivist learning theory stipulates that social and collaborative learning is beneficial to all students, irrespective of gender. Furthermore, socio-constructivist learning theory posits that students learn best through active meaning-making and authentic interactions to construct their knowledge (Vygotsky, 1978; Kanselaar, 2002).

The rest of the OST programs address all children by providing them with collaborative learning opportunities. However, after COVID-19, some of the programs could not emphasize social learning enough. According to the analysis based on the online descriptions of OST programs, Canada Learning Code, The Cube School, and The STEAM Project do not emphasize a social and collaborative learning environment on their websites. Most of their program content has shifted online; however, the programs' content presents few details about how they offer their participants a social and collaborative learning atmosphere. Even if they provide their participant with a social learning environment, it would be good to highlight their virtual content. Adding a social component to the learning environment could contribute to children's STEM engagement (Young et al., 2017). Even if the OST programs are virtual now, they should deliver the same pedagogical approach they provided before this challenging crisis. Most of these virtual OST programs' content depends on individual activities or very limited group or teamwork. In order to create a more effective and efficient social learning environment among children, small discussion groups or collaborative activities could be formed and announced to prospective participants.

Girls' Interests

According to the literature (Blotnick et al., 2018; He, 2018, & Mosatche et al., 2013), OST programs that offer hands-on activities, interdisciplinary projects, real-life challenges, authentic

learning opportunities and more personalized activities for children and especially for girls could make a distinguished contribution to engagement in STEM subjects. Therefore, all the OST programs analyzed in this paper provide children with at least one of the aforementioned activities to gain program participants' interest.

Despite the emergence of the COVID-19, some OST programs have continued to provide activities or content that could spark girls' interest in STEM. Although most of the programs are virtual, some are shipping materials for hands-on activities, such as project kits that will teach concepts in STEAM and create fun and engaging projects for children. For example, the STEAM Project provides pickup and delivery options for hand-on project kits. Moreover, STEM Camp offers engaging virtual activities based on popular themes, such as Star Wars, Harry Potter, Minecraft, and Superheroes for children. The ones primarily based on online tools provide children with real-world problems (Girls Who Code) or daily problems (STEM Camp) and interactive projects (The Cube School).

It is imperative to remember that providing girls with entrance into STEM via "girl interests" does not necessarily mean that it will appeal to all girls. Instead, due to the underrepresentation of girls in STEM, having a wide variety of entrances can be beneficial if the typical programs do not entice or appeal to all girls. In this case, the more opportunities provided to girls to encourage them to engage with STEM, the better, and programs should vary in terms of focus and content to reach more potential participants. However, one should exercise caution when designing STEM programs based on stereotypical interests, as it may alienate some girls who do not possess an affinity for "girl interests" and may form negative self-images ("I am not 'girly' enough"). Therefore, it is important to increase the number of entryways into STEM, to accommodate each individual and to make each individual feel as though they have a place in STEM.

STEM Identity

As stated in the literature (González-Pérez et al., 2020; Wajngurt & Sloan, 2019; Broadley, 2015), providing role models who are STEM practitioners or have STEM backgrounds could be inspirational and motivational and also contribute to the children's identity in STEM-related areas. Girls must engage in STEM by having social connections with women role models with successful STEM careers.

Representations of scientists in media are generally white, and older men and children grow up with this image, limiting girls and particularly racialized girls' interest in STEM. Unless children see themselves represented in these fields, they will have difficulty perceiving STEM as part of their identity. Having women role models and mentors to work with children can change their future for the better. However, it should be noted that many girls and women also enjoy what society presents as stereotypical male pursuits, such as playing video games.

Some OST STEM programs essentially stress the importance of women role models to arouse girls' interest. The Girls Who Code organization, STEM Camp, and ONWiE put into words that inspirational and relatable women role models from STEM fields could effectively appeal to girls to pursue a degree or career in STEM. In this way, girls could mitigate the gender gap by showing they can accomplish anything they want. Therefore, they emphasize the importance of women figures in STEM before and after the pandemic, which is significant to pave the way for girls in

STEM. However, the other programs do not emphasize the importance of women mentors or role models and note that they only provide mentors with STEM backgrounds or without giving specific details. Since it is vital for some children to have inspiring role models without negative stereotypes while building their STEM identities, these OST programs should provide successful women role models for children. Moreover, it could be even more effective for girls to have support and motivation by dedicated women mentors or professionals during their journey in STEM subjects and before they experience a loss of interest in STEM.

The Length of the Program and Early Start

As stated before, the length of the OST programs could play a key role in girls' engagement in STEM. The earlier girls get introduced to STEM-related subjects, the greater the impact on girls' engagement. The analysis of OST programs showed that the length of the subprograms provided varies in terms of content. All of these OST programs also have content for young children. It is crucial in terms of the intervention's timing, directly affecting children's decision to pursue a STEM career. After the pandemic, some of the programs had to change the duration and provide shorter programs to provide an online learning environment.

Providing support and guidance throughout the STEM pipeline is vital to keep children, especially girls, engaged in STEM learning. The Girls Who Code organization, for example, created its subprograms to support girls throughout the STEM pipeline from 3rd grade to college level. If students continue in the programs uninterrupted, they could benefit from consistent involvement from primary school to university. However, it should be noted that, after graduation, some women are still less likely to pursue their careers in STEM fields, according to Statistics Canada. Therefore, it is crucial to create and sustain an unbiased and empathetic working atmosphere that encourages women to stay in these positions.

CONCLUSION

Many OST STEM programs exist, but are they successful in engaging children in STEM? This analysis reviewed some common themes for the successful implementation of OST programs. Because of COVID-19, many students have been impacted negatively. Not only have schools had to make a transition to online learning, but OST programs have been required to change their delivery methods. Therefore, it becomes more challenging to cater to students' interests and needs through virtual or limited programs. Many students also have limited access to hands-on activities and social and collaborative learning environments during this pandemic. With the increase in online educational platforms during the COVID-19 outbreak, it is vital to analyze current OST programs' impacts on children, especially girls.

OST programs could play a crucial role in encouraging girls to pursue a future related to STEM. Therefore, it is significant to have the best applications in OST programs that offer a social atmosphere and collaboration, spark girls' interests, and open the door to a world of possibilities where influential women mentors and role models are available throughout the STEM pipeline. Due to the COVID-19 pandemic, some programs have changed their delivery method, but they should continue to address the same pedagogical approach after this worldwide crisis. Social

community, collaboration among girls, and encouraging women role models should support girls' engagement in STEM degrees and careers.

Although more research is required for best practices' implementations and approaches, the results have shown a need for further improvement and enhancements in OST programs in appealing to children and particularly girls' interest in STEM careers.

Conclusions were limited by when the literature review was completed, and the selected OST programs were analyzed. In addition, because of the COVID-19 and other annual STEM events, the virtual content of the selected OST programs has changed several times. Readers should also be reminded that the analysis was based solely on the online description of the selected OST programs.

Table 1*Examples of Current OST STEM Programs*

Programs	Sub-Program	Covid-19 Pandemic	Social & Collaborative Learning	Girls' Interests	STEM Identity	The Length of The Program & Early Start
Girls Who Code	Clubs	Before	working as a team with their supportive peers build community	working on interactive activities solve real-world problems	STEM professionals	after school program 1-2 hours/week 3 rd -5 th and 6 th -12 th graders
		After	sisterhood of supportive peers build community	engage in fun online coding tutorials solve real-world problems	role models in tech	after school program 1-2 hours/week 3 rd -5 th and 6 th -12 th graders
	Summer immersion program	Before	creating networks	participate in interactive engagements	STEM professionals	Two weeks 10 th to 12 th graders
			(there is no program in Canada)			
		After	supportive sisterhood supportive environment make life-long, inspiring friendships	hands-on, real-world projects	meet inspiring women role models	Two weeks 10 th to 12 th graders
			Virtual Summer Immersion Program			
	College loops	Before	creating a social community	building relations with field experts	girl peer role models	during the year 1-2 hours/week college-age students
			(there is no program in Canada)			
		After	(there is no program in Canada)			

STEM Camp	Summer /Winter STEM Camp	Before	to make new friends and collaboration	hands-on activities challenging problems	the instructor who has a background in STEM	weekly day camp (sessions run for 8 hours) 5 to 13- age children
		After	play with their friends group activities	fun and engaging hands-on activities	the instructor who has a background in STEM	weekly day camp (sessions run for 1 hour for virtual camps) 5 to 13- age children
Ontario Network of Women in Engineering	Go ENG Girl	Before	work in teams	hands-on activities and exhibits	women role models like college students and professionals from the industry	done in a day 7 th to 10 th graders
		After	participate in activities together	hands-on activities	role models from the industry guest speakers	done in a day 7 th to 10 th graders
			Some Virtual Events			
	Go CODE Girl	Before	working in groups	explore various career opportunities in STEM-related fields	meet professionals peers with similar interests	done in a day 7 th to 10 th graders
		After	meet other like-minded students	hands-on activities	meet awesome mentors	done in a day or two 7 th to 10 th graders
			Some Virtual Events			
	Badge Day	Before	with their troop	hands-on activities	to meet inspiring role models	done in a day 5 to 14- age children
		After	group discussion	hands-on activities	meet inspiring role models	done in a day 5 to 14- age children
			Only one program is open for 2021			

Canada Learning Code	Kids Learning Code	Before	collaborative learning opportunities	hands-on activities	industry mentors	done in a day 3 to 12- age children
		After	share with their fellow	hands-on workshop	not mentioned	done in a day 3 to 12- age children
			Online Workshop			
	Girls Learning Code	Before	collaborative	hands-on activities project-based learning	industry mentors	done in a day 3 to 12- age children
		After	share with friends	hands-on experience	not mentioned	done in a day 3 to 12- age children
			Online Workshops			
The Cube School	Virtual Classes for Kids/Teens	Before	There is no detailed information about programs' content before Covid -19 Pandemic			
		After	collaborate	hands-on activities and project-based learning	not mentioned	5 to 12 weeks 60 to 75 minutes in a week 1 st to 6 th graders
	Virtual Camps	Before	There is no detailed information about programs' content before Covid -19 Pandemic			
		After	multiplayer camp activities	interactive projects	not mentioned	weekly day camp 2 nd graders and up
	PA Days	Before	There is no detailed information about programs' content before Covid -19 Pandemic			
		After	not mentioned	enjoyable activities	not mentioned	done in a day 2 nd to 6 th graders

The STEAM Project	Courses	Before	collaboration connections with others	hands-on activities	mentors with STEAM background	10 weeks 1 st to 8 th graders
		After	partner with other children	hands-on experience	mentors with STEAM background	varies from 4 to 10 weeks 1 st to 8 th graders
	Camps	Before	collaborative Learning	hands-on skills	mentors with STEAM background	10 days JK to 10 th graders
		After	collaboration skills	hands-on skills	mentors with STEAM background	10 days JK to 10 th graders

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