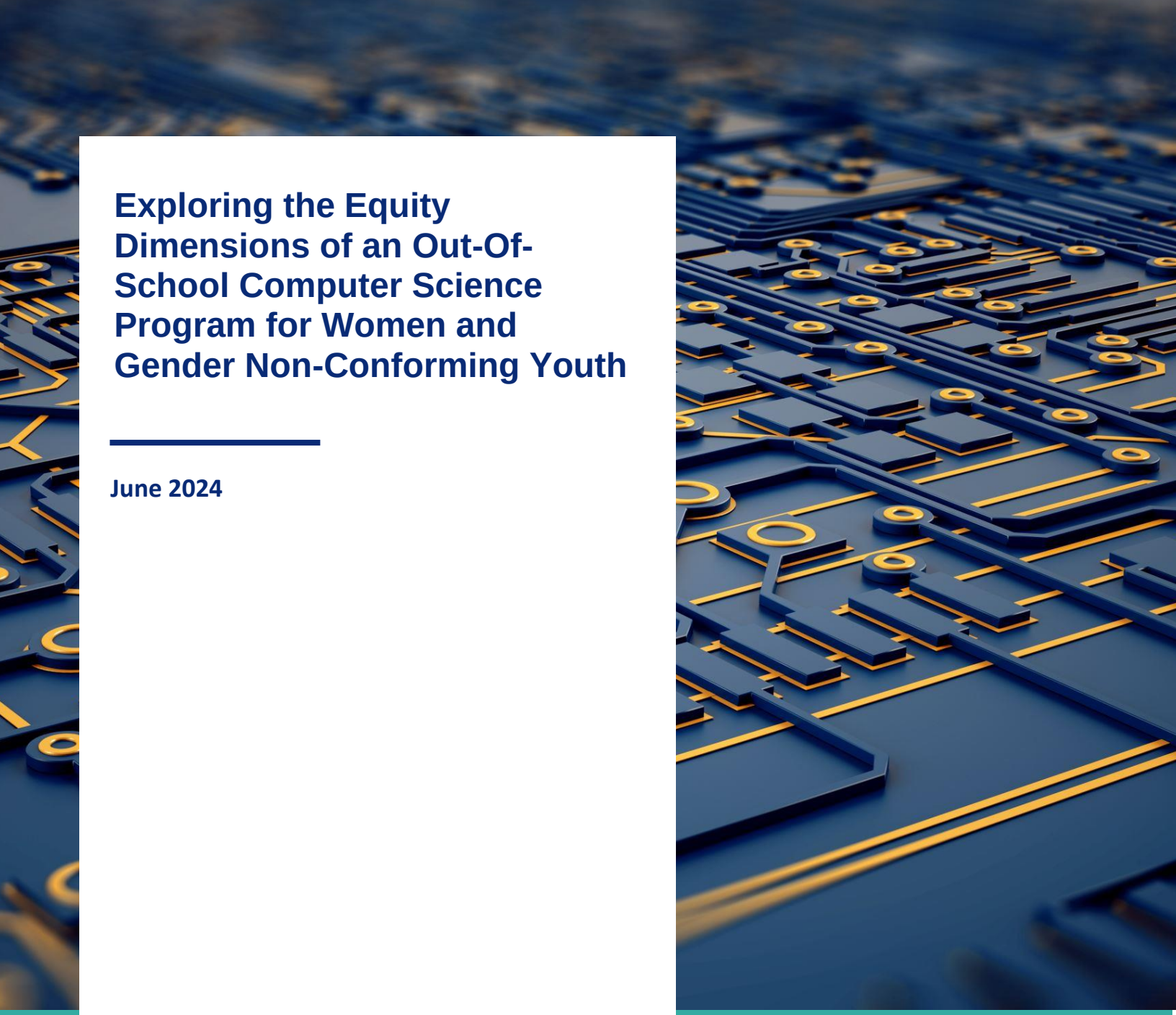

Exploring the Equity Dimensions of an Out-Of-School Computer Science Program for Women and Gender Non-Conforming Youth

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Exploring the equity dimensions of an out-of-school computer science program for young women and gender non-conforming youth

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Researcher Biographies

Lydia E Carol-Ann Burke is Associate Professor of Science Education in the Department of Curriculum, Teaching and Learning at the Ontario Institute for Studies in Education (OISE), University of Toronto. Her research focuses on equity issues in science education and broadening participation in science by exploring the factors that marginalize youth from engagement with science education in both formal and informal settings. Prior to becoming a researcher, she worked for 15 years as a full-time science teacher. She is dedicated to supporting educators as they pursue the development of meaningful and relevant educational experiences for learners.

Ananya Mukherjee is a PhD student in science education in the Department of Curriculum, Teaching and Learning at the Ontario Institute for Studies in Education (OISE), University of Toronto. She holds a PhD in Plant Biology from the University of Maine, USA. Before starting her PhD in science education, she taught Biology to undergraduate students at various universities across North America. Her current PhD research is on tertiary level science education. Her research interests involve public understanding of science and science literacy.

Executive Summary

STEM education made its first appearance in Ontario's elementary Science and Technology curriculum in 2022. Computer science (particularly as it relates to coding, programming, artificial intelligence, and other uses of digital technologies) is a prominent component of the curriculum's new STEM emphasis. This focus on elements of computer science in the school curriculum for all elementary children in Ontario is significant, given the historical underrepresentation of girls and women in computer science education and career pathways. While exposure to computer science education will soon become the norm for **all** children in Ontario, this study explores how an informal, non-profit organization in Ontario (given the pseudonym GirlTech) has been addressing the computer science gender imbalance at the high school level through a program that develops the computer science knowledge and skills of girls and gender non-conforming youth, particularly those living in low-income circumstances. The researchers aim to support GirlTech in the post-pandemic phase of their operations as they consider how engagement with digital technologies has shifted over the last few years. The research identifies key equity elements of the GirlTech program that should be retained and developed as they enter their next phase of program planning.

The study utilized three data sources: surveys of a subgroup of past program participants to explore the evolution of youth experiences with digital technologies over the last few years; interviews with a subgroup of past program participants to delve deeper into computer science experiences, particularly as they relate to the GirlTech program; and examination of GirlTech's program records to understand more about the program's structure and organizational features. The data were analyzed using Fletcher and Warner's equity-focused CAPE framework (Capacity, Access, Participation and Experience), created to assess equity in contexts of computer science education.[1] The data analysis was conducted with the support of qualitative data analysis software (NVivo).

The findings indicate that young women and gender non-conforming youth living in low-income circumstances in Ontario have all had a rapid and recent increase in exposure to digital technologies due, in no small part, to the pandemic and the need to learn how to study, work, and conduct leisure activities online. GirlTech provided a strong illustration of the tensions at play when an informal education provider seeks to promote greater equity in out-of-school computer science programs. The program's emphasis on providing participants with mentorship from computer science professionals and university students gave attendees direct access to role models who could help them navigate through personal, professional, and academic goals. The building of these relationships was most effective in person (but could be maintained online). In addition, GirlTech helped some of the youth to

[1] Fletcher, C. L., & Warner, J. R. (2021). CAPE: A framework for assessing equity throughout the computer science education ecosystem. *Communications of the ACM, 64*(2), 23-25.

secure scholarships and internship opportunities, supporting their continued engagement with computer science once the summer program had ended. Without the skills and direct networking opportunities afforded by the GirlTech program, youth are unlikely to have had access to such scaffolded opportunities to be inducted into the computer science field. GirlTech also provided the youth with high-configuration laptops and high-speed Internet access at home, if needed. The laptops were used by the youth while completing the program and to support them in school and/or home contexts where they could tinker with applications and programs beyond the scope of the GirlTech schedule. The majority of the laptops distributed were retained by program participants for continued study and personal use at the end of the program. This report explores the issues associated with implementing and maintaining these and other equity measures. We explore the potential for maintaining such a meaningful, equity-focused program, despite recent fluctuations in enrollment, given that many youth in the target age bracket for the program might need to work during the summer months and have recently become accustomed to learning in online rather than in-person contexts.

Introduction

The computer science (CS) field has faced many challenges concerning equity and inclusivity as, historically, it has failed to attract and retain women and gender non-conforming participants. In addition, youth living at the intersections of race, gender, and/or socioeconomic minoritizations might find it hard to follow a computing-related career trajectory. Cultural stereotypes about who can participate in the CS field can deter minoritized learners from studying coding, artificial intelligence, and other computer-mediated subjects; these stereotypes can be reinforced by a learner's lack of exposure to the field, discourses carried in the social and educational contexts of the learner, and/or biases of educators when teaching or advising minoritized learners. The fact that CS experiences are often heavily reliant on high-cost devices and reliable, high-speed Internet access, can create another accessibility barrier for the learner. The resultant dearth of role models for today's girls and gender non-conforming youth in the CS field can make it difficult for gender-minoritized youth to see themselves following the CS career path.

For over a decade, many informal learning providers have raised concerns about access to technical and academic CS skills in North America. These institutions have attempted to redress this CS imbalance by focusing their efforts on groups that are underrepresented in CS career pathways, mitigating the financial burdens associated with CS access. The study described in this report focused on the equity strategies employed by GirlTech[2] as well as the experiences of girls/young women and gender non-conforming youth who had enrolled in one of their informal STEM summer programs over the past 10 years. We aimed to explore how GirlTech's approach could be interpreted in light of the equitable intentions of the organization and recent and necessary shifts in exposure of youth to digital technologies.

[2] GirlTech is a pseudonym.

Exploring Equity

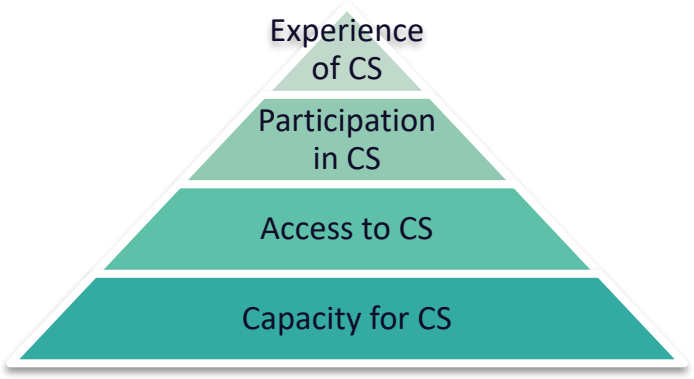
While computer programming, robotics, and artificial intelligence have gained prominence over the last few decades, gender inequity in CS education has remained an issue. The Government of Canada's recent investments in STEM education initiatives, highlight concerns for women and other underrepresented groups in STEM fields;[3] this situation is even more pronounced in the computer science domain. Researchers Fletcher and Warner (2021) suggested that, rather than focusing on evaluating participant gains once a CS program has ended, equity measures should be intentionally incorporated into the fabric of any system of computer science education.[4] Warner et al. proposed that program planners utilize a framework of four interrelated components of equity in CS education:

- Financial and human ***Capacity*** of the program
- ***Access*** to education for those who are marginalized
- ***Participation*** in CS by the underrepresented groups
- Learner ***Experience*** of achieving and persevering in CS K-16 education.

Collectively, these components form the CAPE framework. Most equity-related research in CS education addresses the access and participation parts of this framework but GirlTech has been focused and intentional about seeing their learners as part of the broader context of CS education and careers. This study uses the CAPE framework (most commonly used in the formal educational context) to examine what the various elements of this equity framework look like in a system of informal CS education, illuminating the tensions that exist when attempting to balance all four of its elements.

Figure 1

Fletcher and Warner's CAPE framework for equity in computer science systems



[3] Government of Canada. (2021, August 13). The Government of Canada and STEM. *Choose science*. https://ised-isde.canada.ca/site/choose-science/en/government-canada-and-stem

[4] Fletcher, C. L., & Warner, J. R. (2021). CAPE: A framework for assessing equity throughout the computer science education ecosystem. *Communications of the ACM, 64*(2), 23-25.

Research Objectives

The following research objectives guided the study:

1. *Identifying contemporary experiences of young women and gender minoritized youth with digital technologies*
2. *Understanding the impact of GirlTech's equity-focused strategies on the computer science experiences of program attendees*
3. *Exploring the implications for more equitable approaches to informal CS educational provision in Canada*

Research Context

GirlTech is a non-profit informal STEM organization that supports young women and gender non-conforming youth, usually living in low-income neighborhoods, as they negotiate their relationships with computer science career pathways. The program described in this study was launched in 2018 (with an earlier iteration being trialed from 2014) and is focused on providing the youth with a 4-week (Monday to Friday from 10 am to approximately 1 pm), immersive experience that focuses on development of academic as well as professional computer science skills. Daily activities included talks/webinars, guided coding instruction, group seminars/discussions, and group project sessions. The coding instructors were post-secondary students and industry professionals mentored the program attendees and the coding instructors. Attendees worked in mentored small groups to complete an authentic industry project, the product of which was presented to industry clients. Working alongside industry partners who bring the youth into authentic business contexts, GirlTech program participants learn design thinking, coding, app building, prototyping, analytical thinking and problem-solving, business and leadership skills, and how to pitch business ideas. Youth from all over the province are accepted into the program but, most commonly, only those living within a 2-hour commuting distance of the downtown core of Toronto are able to participate due to the need to access learning spaces provided by industry partners.

14 youth, aged from 17 to 22, participated in this research study. 13 identified as women or girls and one identified as non-binary. 13 of the 14 participants attended the GirlTech program between 2019 and 2023. At least 6 of the participants had enrolled in the program more than once (as is encouraged) which means that they were able to share perspectives from their experiences of the usual in-person format of the program, as well as the emergency measures remote iteration and subsequent hybrid formats. At the time of data collection (2023), the participants were high school students, undergraduate students, or working (some of the students were also working part time). The program has a capacity to accommodate around 20 youth for each 4-week session and includes a combination of presentations, demonstrations, team projects, and guided skill development sessions.

Research Methods

There were 3 data sources for this study:

1. Program reports and website information describing the processes and approaches used by GirlTech
2. Web-based surveys describing the background and context of digital technology experience for 14 of the GirlTech program's past participants
3. Individual interviews with 11 past participants of the GirlTech program to expand upon responses provided in the surveys, with a particular focus on equity concerns.

The survey consisted of 38 items divided into five subsections exploring the following categories of experience: online learning; devices; Internet access; CS skill development; and the impact of the pandemic. Each item was rated on a 7-point Likert-type scale according to each participant's level of agreement. The survey contained a free response box at the end of each subsection to allow participants to explain their responses more fully. Interviews were conducted via videoconferencing and verbatim transcripts were produced. Interview data was coded with the support of NVivo software, starting with codes determined by the CAPE framework (capacity, access, participation, and experience) described above.

The findings are organized into two sections. The first subsection of the findings provides an analysis of the survey that dealt with youth experiences with digital technologies to provide a background of understanding about contemporary experiences with digital technologies. The second part of the findings summarize the themes that emerged from the equity (CAPE) analysis of the organizational documents and individual interview transcripts.

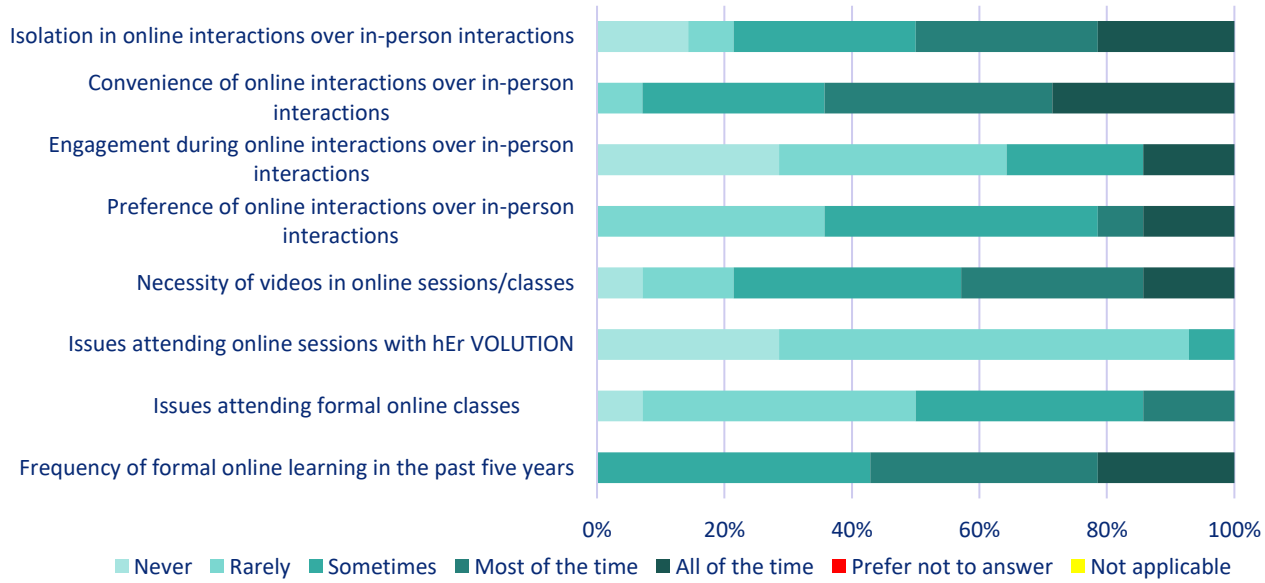
Contemporary Experiences with Digital Technologies

General Attitude Toward Use of Online Learning Contexts

Although online learning was described as being more isolating than in-person learning, most of the participants had extensive experience with online learning through their formal education courses over the last five years. This means that not all of their online learning could be attributed to the pandemic remote learning period. Participants asserted that online learning was more convenient than in-person learning. This point was illustrated by Morgan who said **"I find it easier to engage in online classes and webinars as I'm in the comfort of my home, there are minimal distractions, and I get to engage with the material at my pace. Additionally, it saves time from commuting and is overall more efficient in our digitized world".** Some acknowledged the convenience but found it more difficult to engage in online spaces; as described by Bailey, **"it seems to be more difficult to engage in online sessions and stay focused for the same amount of time"**. The participants faced more issues while attending online classes for school/college/university than in their GirlTech sessions; as stated by Peyton, **"the mentors in the program were very open and engaging, and understood when there were internet issues"**. Interviewees described ambivalence when reflecting on balancing the convenience of attending classes from their homes with the lack of social interactions; for example, Bobbie stated **"it was very difficult for me and my team to talk out any disagreements we had"**. Some participants suggested that the flexibility and relative anonymity of online sessions were more important than the need for social engagement (which suggests that online learning may become more of the rule than the exception in the future). Figure 2 summarizes participants' survey statement rating responses.

Figure 2

General experiences with online learning

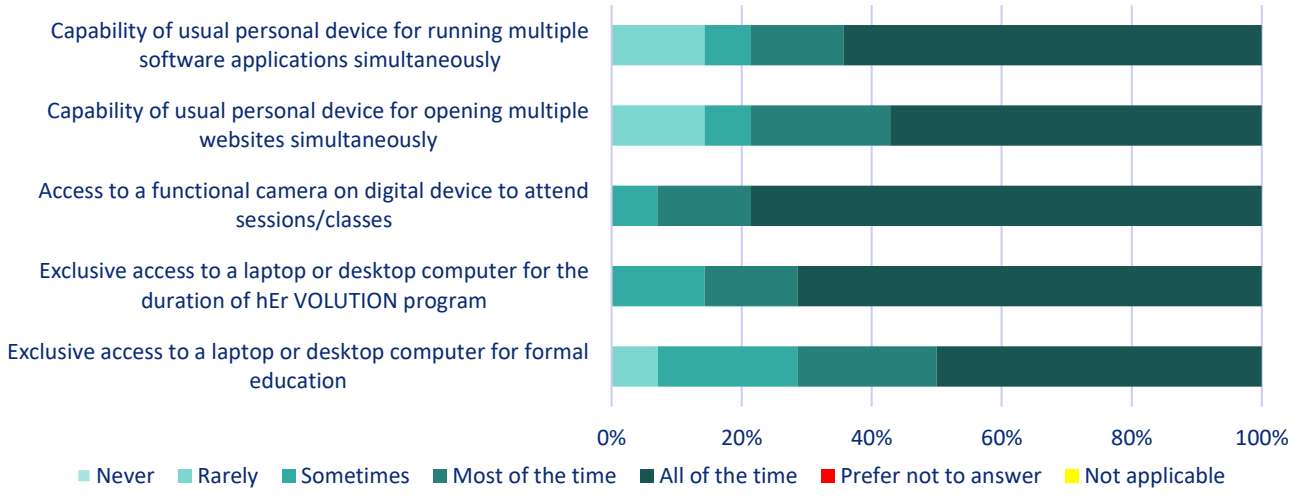


Access and Capabilities with Digital Devices

Most of the research participants did not have any device-related issues when accessing educational resources or learning environments, either within the formal education system or when attending the GirlTech program over the past five years. A high proportion of the participants in this research study (86%) stated that they received a laptop (or, in one case, an iPad) from GirlTech. Morgan explained how transformational it was to receive the laptop: **"After I was provided with a laptop, I faced no barriers"**. Peyton had a similar experience: **"I received a laptop from [GirlTech] as my laptop was not capable of running multiple screens at the same time. The laptop provided was definitely helpful, and aided me not only for the program, but for school-related work as well!"** A few participants faced issues with the processing capabilities of the devices they had available before joining the GirlTech program. As explained by Nova "**The other device that I was initially going to use was provided by the school and although it was good, it did not allow me to properly split screens and learn, it would glitch often and I could not download important applications I needed such as VS code. This is why the [GirlTech-supplied] laptop helped tremendously with the learning experience".** Once provided with a high specification device, participants' hardware concerns were alleviated, and they were supported in completion of tasks for formal and informal educational settings. For a number of the participants, the laptop supplied by GirlTech was still being used as their primary computer years after completion of the program. Figure 3 illustrates participant responses to survey statements about digital device experiences.

Figure 3

Experiences with digital devices

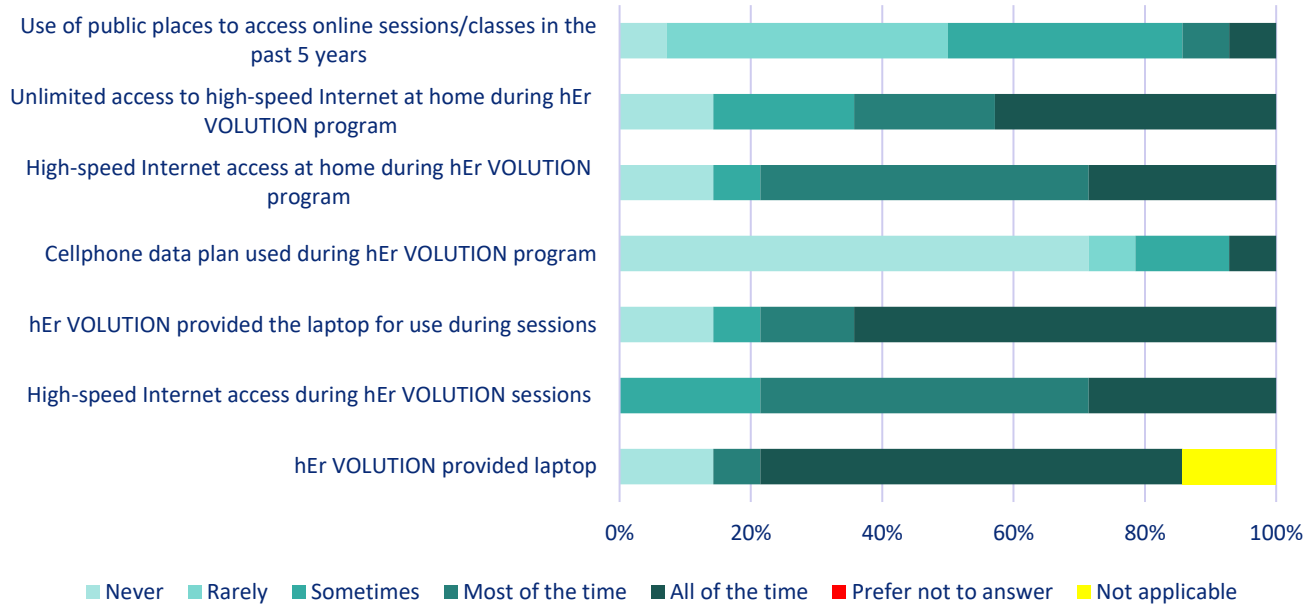


Internet Accessibility During Online Learning

Most of the survey participants described having Internet access at home, prior to joining the GirlTech program; very few had to use cell phone data plans or public spaces to participate in online learning. Morgan stated: **"I've always had access to reliable and unlimited internet service"**, similarly, Winter wrote **"Thankfully, my house's wifi was good enough to support the program".** It seems that predictable Internet access is likely necessary for any learner who has already experimented with computer science skills in their own time, prior to following up on this interest in a formal or informal learning space. A few program participants stated that they did not have ready access to Wi-Fi Internet at home; Lo stated, **"I was given a wifi stipend for both times that I attended the program!"** It would have been interesting to hear how this participant developed enough of an interest in computer science to enroll in the GirlTech program, but no further detail was provided. In fact, prior to enrolling in the GirlTech program, some participants were unaware of the strain that computer science applications can place on shared Internet accounts; these participants did not initially sign up to receive the Wi-Fi stipend. This is explained in comments made by Bobbie and Ash: "**At home, my wi-fi was not as good as my whole family was on it but I had access to public libraries or cafes at the time too**" (Bobbie) and "**Sometime internet was slow and it made it hard to run certain programs**" (Ash). Figure 4 summarizes participants' survey responses relating to Internet access.

Figure 4

Internet accessibility

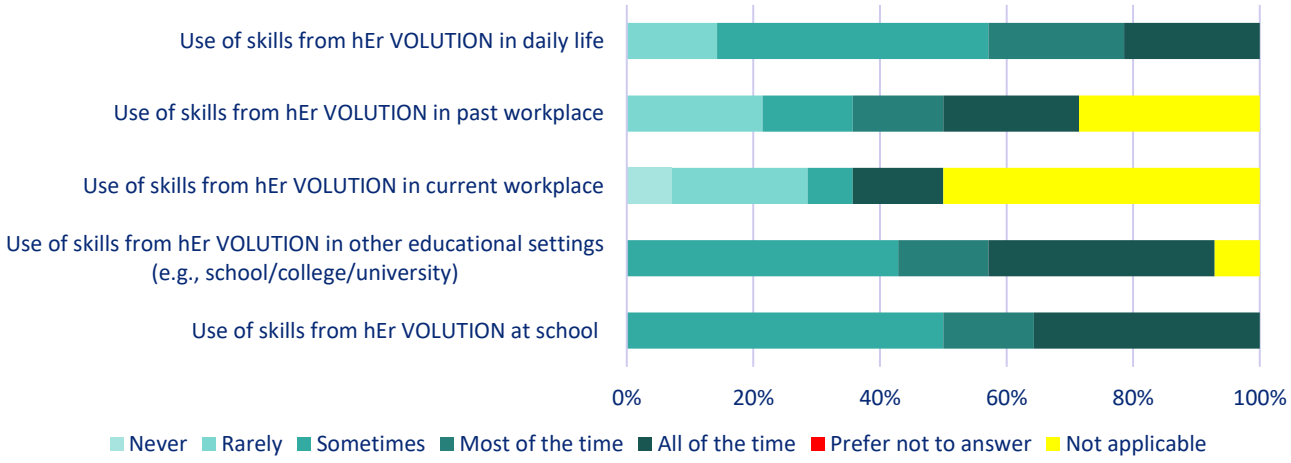


Computer Science Skill Development

Participants described the GirlTech program as helping them to develop skills that were very relevant to their academic journeys, both at high school and post-secondary education levels. The ability of a number of the study participants to pursue computer science and other science-related degree courses is a strong indication that, at the very least, the GirlTech program was able to maintain the interest of the participants in STEM education. As described by Nix **"I developed skills using a computer and some coding as well as professional development which I use a lot. Definitely getting more comfortable using technology and learning some coding was the biggest thing"**. Given that many contemporary STEM-related degrees feature aspects of coding and programming, these skills were helpful to all participants. This point was reinforced by Bailey who stated: **"Although I did not pursue a major in computer science, the coding skills I developed in the [GirlTech] program were useful when I encountered code later in high school/university. I had enough foundational knowledge to quickly pick up new coding concepts that were necessary to perform the tasks I wanted to do"**. Other participants also described the development of the broader spectrum of skills that would be useful in a range of work or educational contexts. As described by Peyton **"Communication, especially in a virtual setting, is something I worked on as a program participant for [GirlTech], and it has drastically improved from when I started the program"**. Winter described a related experience: **"Although I have not entered the work force, skills such as pitching and networking have been extremely helpful in my classes and when trying to make new connections at different events".** It should be noted that a number of the survey participants were still in high school so did not have a first-hand job- or higher education-related experience. Figure 5 summarizes survey responses.

Figure 5

Skill development

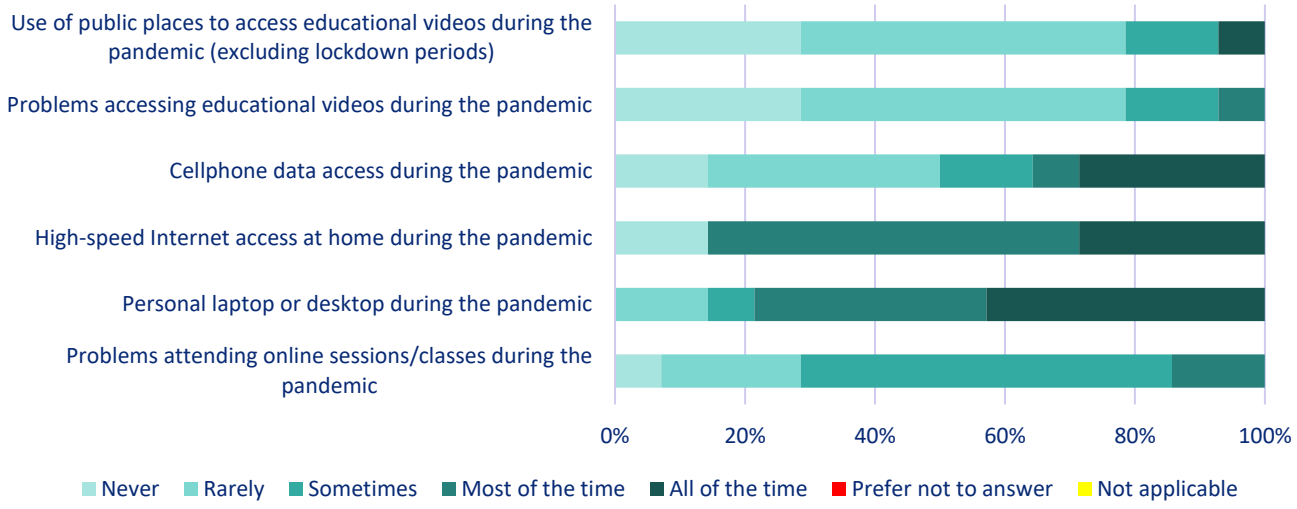


Computer Science Learning During the Pandemic

The digital access effects of the pandemic were not that different from the everyday issues with connectivity or device availability that the study participants had faced before the pandemic. However, while the lockdown period provided opportunity for some learners to reinforce their relationships with computer science, others found that the absence of varied, group-based learning opportunities presented challenges. These ideas were well articulated by Peyton and Nova: **"as the pandemic was restricting, I found myself at home for most of 2 years, and thus was mostly found on my laptop, using the internet at home"** (Peyton) and **"it was also a little less engaging to learn as learning followed the same format. I didn't get to know my group members as much as I would have like [*sic*] to either"** (Nova). The sporadic Internet connectivity was felt all the more keenly during the pandemic when there might have been multiple people in a single household needing space and connectivity to conduct their individual meetings. This was the point at which it was obvious that sharing devices was less viable than it might have been before. Winter summarized this idea: **"During the pandemic, I occasionally had difficult wifi problems, as my parents are both teachers and I have two younger siblings, meaning at times there were 4 to 5 people using the Internet at the same time. This was not a problem during the summer, as I was usually the only one who was attending Zoom calls/Google Meets, but pandemic learning was difficult for my family"**. This issue of distracted living also impacted video conferencing capabilities, as described by Bailey: **"I think there was a sense of fatigue amongst myself and my classmates during the online portions of high school. I felt that it was more difficult to retain information learned in online school (possibly because of how easy it is to 'zone out' online and stop paying attention)"**. The pandemic's emergency measures resulted in half of the participants regularly using their cellphone data plans to access online classes. Figure 6 summarizes computer science experiences during the pandemic.

Figure 6

Computer Science During the Pandemic



An Equity Analysis of Computer Science Education Through the GirlTech Program

The analysis outlined below uses the CAPE (capacity, access, participation, and experience) framework to provide insights into the equity strategies employed by GirlTech and the program attendees' experiences of those strategies (as described by our research participants). This analysis is organized into four themes: *Provision of Appropriate Resources*, *The Pivotal Role of Mentorship and Networking Support*, *Learning for Life Beyond the Bounds of Education*, and *Lessons Learned from the Pandemic Experience*.

Provision of Appropriate Resources

The ***capacity*** of GirlTech to support youth in development of their CS-related knowledge through provision of computers and Wi-Fi stipends, if needed, was one of the major themes to emerge from the study. Prior to joining the GirlTech program, a number of the study participants did not have full time, exclusive access to a personal computing device; as described by Cedar, **"before [GirlTech] … I always had to share, like, a laptop (because it's, like, pretty expensive) with my siblings"**. Cedar went on to explain that they had attended the program twice and received a laptop on loan for the duration of the first time taking the program but were able to keep the computer when enrolling for the second time. Through their various funding and sponsorship arrangements, GirlTech organized their budget to prioritize provision of Wi-Fi stipends and computers for attendees, if there was a demonstrated economic need. Morgan provided a personal account that explained why the laptop was needed to complete the program: **"during this time I was using my brother's old laptop. It wasn't the best, the camera quality, none of that was good. I needed that to be engaged in the program, since it was completely remote at the time. They provided me a laptop for free, which is very nice of them"**. Kennedy described how issues of computer access were accentuated by the pandemic: **"I have 3 other siblings. So, it's 4 of us, total, and we were all in school, so there was a lot of sharing going on. There wasn't that many computers in the house for all 4 of us to be doing school, which kind of, it was a bit of a setback … So, I used a [GirlTech-supplied] laptop for both years and in the middle, I would use it for school and other things like that"**.

The computers that were provided by the program were helpful for the participants both to further their education and to support them in other ventures. Nova described being able to establish and support a flourishing small business due to the high specifications of the GirlTech-sponsored computer: **"So it took me a long time to be able to do things with the Chromebook [on loan from school], but then, when I got the laptop, which I think was like about a year ago, I think, it really changed up because I was able to, like, have multiple tabs open of, like, things that I was reading about like, you know, businesses and, like, things that I want to try out and my website open so that I can learn how to, like, develop my Squarespace website, right, where I could watch a video while also doing it alongside. And so, it also has more space on it. So, whenever I need to download something for my**

business … I'm able to store all my photos and then upload them to my website". Nova and other program participants were able to see how the provision of a high specification laptop improved their abilities to develop and use their computer science skills in ways that were meaningful to them, supporting broader definitions of ***participation*** in computer science.

Similar to the account provided by Nova above, a number of the research participants' accounts revealed that, prior to the GirlTech program, they had an inadequate understanding of the Internet and computer specifications that might be needed for effective engagement with computer science tools. This appreciation of the vastly improved experience that can be gained from a high specification machine was described well by Vesper: **"so I, like the first year of [GirlTech], actually didn't have a laptop. So, my brother, he had this tablet and, like, I didn't have a laptop at the time. So, that's what I used to do [school] work and then I entered, like, the program. And this was a really nice part, like, they gave us all a laptop to use like during the duration of the program, which I really, really appreciated. It was like, it's just hard to do coding on a tablet but, like, on the laptop, obviously much, much easier, which I really appreciated. And I think, like, it really helped with the learning experience more. I don't know there's something about the laptop versus the tablet … it [the tablet] would just randomly shut down. It was just so inconvenient"**. Orion also explained how they discovered the need for a higher specification device: **"So, I could run basic websites, maybe open a textbook, but that was a lot for my computer. So, it was definitely not pleasant because, you know, it would crash in the middle, all my work would go away (unless it was like Google Docs, and it would save), and then I have to turn it back on hopefully and just wait … Also, I was big on computer science, learning how to code. I could not do any of that on my computer. I'd wait for my older sister to be done with her computer and then I'd go on"**. There were numerous descriptions of computers being slow or Internet access dropping. Fortunately, for some, they were able to figure out that they needed to request the upgrades offered by GirlTech. Participants were extremely appreciative of the resources provided through the program.

As a non-profit organization, whose policy framework is likely to evolve over time, depending on the extent of outside funding, GirlTech has adapted their strategy with regard to laptop provision. There has been a shift from providing youth with iPads to offering MacBooks. Similarly, early policies allowed program attendees to retain the computers only if they attended the program twice (in the summers of two consecutive years) or completed a shorter introductory course followed by the longer GirlTech program. This policy provided the opportunity for continuity and reinforcement of learning over a sustained period of time. However, there was some confusion associated with laptop ownership. Youth who intended to complete the program more than once, but found themselves unable to do so, were confused about whether they could retain the laptop. As described by Morgan: **"I was only in the program for one year, because I think after that I was going into Uni … it was, like, it was more of a borrowing thing. I would, like, return it at the end. But I believe that if you're in the program for, like, 2 years, I think you get to keep the laptop. So, I think that's a nice incentive, for sure".** Indeed, Kennedy described purchasing a computer after the GirlTech program had ended due to a lack of clarity

regarding ownership of the laptop that was supplied by GirlTech; Kennedy explained: **"I asked when I was supposed to return it, and they told me that I could use it the next year for school and then the year after because I did the [GirlTech] program for 2 years. So, I used the laptop for both years and in the middle, I would use it for school and other things like that … I know that I am supposed to give it back"**. Even if the laptops were not permanent acquisitions, the youth were extremely appreciative of the ability to have such a high-quality computer in their personal possession; as Cedar stated: **"they gave, like, a MacBook and actually that's, like, the first time I touched a MacBook, like, I've never touched a MacBook before"**.

The Pivotal Role of Mentorship and Networking Support

GirlTech's tight collaboration with organizations in the computing field provided their program attendees with access to personnel at various levels of computer science education and employment. These personnel included undergraduate computer science students who served as coding instructors (guiding attendees through acquisition of various CS skills and knowledge) and industry computer science professionals who made guest presentations and served as mentors to undergraduate instructors and attendees (during their project development). All of these personnel were readily described as mentors who had relatable CS journeys and educational ***experiences***. Rudy described the relationship with their designate mentor: **"I felt like, with my mentor specifically, she really helped me in terms of being open to one-on-ones and also, kind of, engaging her students as well. So, that definitely helped and also, we are able to use, like, Slack and also ask her questions that way as well"**. Lo spoke about how inspiring it was to work alongside other young women, all of whom were performing and achieving in computer science: **"there was a lot of mentors who are there to support me in that project. And I was working with a group of students. They were all girls, and even, like, being in that group of students, like, everyone in that group, was so inspiring as well"**. Orion reinforced the idea that **"we built that trust with each other, and it didn't matter what age or who that person was, but because we had built that bond and that trust when it came to actually learning in [GirlTech], we weren't afraid to say we didn't understand something … It's computer science. It's coding. Look, in the beginning I was, like, what is this? I don't understand what's happening … we had good trainers, they were very supportive. They were kids in university. So, I feel like, because we had younger people teaching us, they kind of understood where we were coming from, because they've been through that path too."**

The interconnection of educational and employment experiences within the program helped attendees to see the direct connection between what was being learned and how people work within a professional computer science setting. Indeed, the travel bursaries provided by GirlTech gave participants ***access*** to workplace locations for the instructional sessions so that attendees could gain firsthand workplace ***experience***. Cedar described how transformational that experience was for reinforcing their place in CS: **"it gave, like, representation, like, I saw different people, like, different faces. Like, it's super diverse. And because in, like, school, it's really hard to find representation. It's, like, super male dominated and it's, yeah, it's, like, intimidating, definitely. To see myself, like,**

coding, like, even for me, like, sometimes when I think about, like, computer science, I just think about, oh, it's probably, like, some white guy who does, like, coding like Mark Zuckerberg or something like that". GirlTech was very intentional in their selection of industry partners where attendees could meet women in pivotal leadership roles, challenging the stereotype of the typical computer scientist. This messaging seemed to be received by program attendees like Lo who explained: **"I saw a lot of women who were kind of just like me, and I also, I really identified with a lot of the women who said that they were, like, earlier in their life, they were more, like, shy and more reserved, but they were still able to, like, thrive in this tech, this career and this field being how they are, and never really having to change themselves, and that particularly, like, that really resonated with me, and that was really, like, inspiring for me, personally."**

Cedar's comment above reinforced how empowering it was for the youth to see a diversity of women taking up significant roles in the computer science industry. Peyton went further to describe how diversity was also reflected in the program attendees (drawn from across the province), reinforcing the idea that computer science really can be for anyone: **"there was, like, a couple of hijabi girls as well as, like, some Indian girls, there was an African girl, I believe there was also an Asian girl there. Yeah, so we were all, it was all kind of like a diversified group, and we, like, we used our culture, our own cultural touches, like into, especially in our personal characters. So, when we were making our game, we had to make our personal avatars. So, we put our hijab icons. It was kind of cute".** As program attendees worked together on authentic problems with an authentic business space, they considered the program to be a realistic taste of the work carried out by computer science specialists, and could see themselves fitting in well within the work environment. Vesper explained how incidental moments within the program could have a large impact on the attendees' career trajectories: **"I met, like, someone from [a high-ranking Canadian university] that came by to one of our guest lectures, that actually really helped my university application to [the university] itself 'cause I got to, like, talk about that experience. I don't. Yeah, I don't think ever mentioned like how much that helped me. I actually got into [that university] because of that. Like, it was a great experience. I talked with them. I mentioned it in my, like, application, and it just really made me look forward to the future."**

As part of the GirlTech program, attendees were introduced to internship and undergraduate co-op learning opportunities, facilitating their ***participation*** in a scaffolded/supported entry into CS careers. Kennedy explained why it was so important to be supported through a program that created a tangible link to higher education: **"there wasn't a lot of people that I knew from where I was or where I was from that was also in STEM … I think I am the first, from my dad's side to actually go to university … So, I would look up to other mentors from companies and school and things like that rather than like within, like, family and culture and stuff like that"**. Rudy had a similar experience: **"our mentor was able to, kind of, answer questions that were out of scope of the [GirlTech] program. Although she was a university student, she was able to, kind of, bring her experiences of, like, internships, hackathons, and, like, just, like, other experiences, we can have outside of the [GirlTech] program"**. Lo explained how hard it is to know what CS jobs look like from the outside. It is rare to have an

opportunity to experience an industry context on a day-to-day basis. Indeed, Lo appreciated these experiences so much that they volunteered to be on the GirlTech program planning committee to bring an attendee's first hand feedback into the planning process. Morgan had a similar experience of continuing the program connections even after the program had ended: **"I think I genuinely fostered a deep connection and, like, that feeling of support from the mentors at [GirlTech]. I've never had mentors or anyone guide me before, but they were very passionate and enthusiastic about actually, like, having us succeed in the program and actually build something we're proud of. So, I definitely felt understood and supported, and I still feel understood and supported, like, if I ever need anything, I'm able to reach out to those mentors I had, and that's really cool"**. Thus, the reach of the GirlTech program is beyond the initial 4-week experience, providing a space where long-term industry connections can be fostered.

Learning for Life Beyond the Bounds of Education

As described above, the participants reported two types of educational opportunity that extended from the GirlTech program, but which are rarely incorporated into informal education programs. One is the opportunity to explore how knowledge gained through CS degrees is applied and used in real-world projects. The other opportunity is that of different types of internships and scholarships. There were mentions of ***access*** to professionals in computing fields who provided information about scholarship programs for post-secondary education which would otherwise have been unknown to many of the program attendees. Lo described how their current situation had been impacted by these opportunities: **"So, right now I'm working as a software developer intern. And so, a lot of the skills are transferable, like, a lot of the communication, collaboration, working in a team working with superiors, working with mentors that whole, like, culture is basically the same … And once I was in the program we also had, like, a couple of writing activities where we had to reflect upon our project, and we also had a demo day at the end of it, where we had to do like a big final presentation, presenting our final project to like [industry partner] employees and other people. And so that was really great practice, for, like, sort of what I would have to do in my internship".** Orion described receiving a four-year scholarship to complete a CS degree that included an integrated internship. Orion explained the details of the degree arrangement: **"this summer I went through, like, 5 rounds of interviews, and I got it! So, I'm like, thanks to the laptop and [GirlTech], like, I don't have to worry about where my money's gonna come from, for like university and stuff like that … they [the industry partner] have their program called [a specific CS degree] … I'm going to [a local university] … your curriculum and your internship work side by side".** Such opportunities to combine real life applications while completing rigorous undergraduate studies are very rare in science-related fields.

Another aspect of the GirlTech program that is rare in science education fields, is the ability to participate in the program more than once. Usually, in formal science education, the educational trajectory is linear and sequential so that underperforming at any stage results in falling out of the system, long-term. By providing youth with multiple opportunities for engagement with computer science, GirlTech combats the notion that excellence in a field is innate; rather, the program caters to

learners with very different levels of experience and expertise in CS and exposes them to different educators so that they do not have to rely on a single educational event to determine their continued engagement with CS. Vesper explained how repeating the program allowed for exposure to different instructor styles and opportunity to have a second chance at learning based on different instructional approaches: **"It's just important to, like, be able to explain coding. And, like, some people, just don't get it naturally so like if I'm trying to learn it in class, I have to make sure it's like thoroughly explained and, like, put in a way that I understood."** The GirlTech program provided scope for solidifying and reinforcing learning by repeating a program that had different contextual elements from one year to the next (due to the authentic problem-solving carried out in the projects).

In addition to outlining educational pathways into computer science careers, a number of the research participants described additional skills that they developed through the program that could be helpful in everyday life, even if they do not follow a computer science trajectory. Nix described how important coding seems to be for a range of science-related degree programs: **"I don't think I actually really knew what [coding] was. Like, I'd seen movies where there'd be like someone just kinda like type really fast and go like, 'oh, yeah we've hacked in' or something, but I didn't really know what it was that much so it, kind of, they conceptualized it better and I understood. So that was something that was definitely big. And when I went into the [GirlTech] thing, there was a really big emphasis on professional development and skills in terms of, like, pitching your, like yourself and like your strengths and coming up with ideas. And entrepreneurship, like that was the whole like … website idea was like think of like a problem and then come up. So, and those are things that I definitely use all the time in engineering school and, like, I'm on co-op right now".**

Participants seemed to be aware that the GirlTech experience was rare and opened doors for them to consider computer science-related careers. Nix expressed appreciation for the opportunity to keep STEM pathways open: **"I really appreciate everything [GirlTech] is doing to inspire girls to learn about and possibly pursue STEM. I am in engineering, and I believe the [GirlTech] program I did had an impact on my decision to study engineering"**. Lo, who is currently pursuing a computer engineering degree, expressed a similar sentiment: **"The [GirlTech] program really helped change my life and career for the better! I encourage all younger female identifying individuals to get involved!"** The life lessons gained through the program were critical for exposing the youth to previously unfamiliar aspects of certain STEM professions. This point was illustrated by Morgan: **"there's so much more to computer science than just coding, 'cause you have, like, that social aspect with the team, all the design. There's also lots of art involved, and a lot of business and entrepreneurship and leadership, and I never associated computer science to all of that before."**

Research participants also highlighted their development of certain 'soft skills' such as communication and collaboration; Cedar explained: **"in terms of the soft skills that I learned from [GirlTech], I think, communication is super important, like, they, like, making friends and talking with professors, you know, approaching them. Like, it helped me in terms of, like, learning how to talk with professionals,**

I guess, cause, like, in school it's, like, I talk with, like, teachers but they're, they're laid back. They are professionals, of course, but they're also, like, laid back and it's less corporate-y-ish … aside from, you know, the technical skills, I also learned soft skills which is, like, communication and, like, collaboration with people, presentation skills, which is, oh God, so important." Alongside their development of these more commonly used transferable skills, participants described their exposure to a range of different communication and coding applications and platforms that could readily be used outside of CS context; these included JavaScript, Python, Figma, and Discord, Slack.

Lessons Learned from the Pandemic Experience

The forced shift of the GirlTech program into an online space for two years during the pandemic period illustrated what is lost and gained when operating a program within an online space. The most common point raised by the participants was the ease of accessing online education from their homes. This was mostly considered to be a positive development as youth could access quality education without the hassle of time-consuming commuting. While acknowledging some of the challenges of online learning, Cedar described the convenience of the shift to online settings for formal and informal education: "**So, it was really convenient. I saved a lot of time as well as money when I didn't commute, like, I just was on Zoom … I really like the flexibility and I like that professors they would usually record the video and I can, like, look back at it and you know it's, like, if I have to go to a doctor's appointment or, like, go to a clinic, then I won't miss that much**."

Some of the participants mentioned issues they had with in-person informal education. One of these issues was the time and expense of commuting from outside of the local transit zone (GirlTech provided local transit bursaries for travel within the Toronto region during non-pandemic times). Some participants who attended during the pandemic period suggested that they might not have been able to participate in the GirlTech program if it was in-person. Kennedy was one participant who may not have attended if the program was not entirely online because the online context facilitated being enrolled in multiple programs at once: **"As much as I really did not like the online experience, it was very convenient, because I, especially my second year, I tended to be very busy, so I was sort of, was doing like two programs at once, kind of thing. And I would literally have, like, one tab with one program, and another with another program. So, just because it was virtual, it really helped with, in case, like, schedules didn't work out"**. A few participants pointed out that the lack of social interaction in online environments was isolating, but that did not outweigh the gains in flexibility and convenience, as program attendees were still able to remotely access educators and learning. Bobbie described the gains and losses of online learning from their perspective: **"It just feels easier to learn, and I also lost, like, the social aspect, because, like, we're online, and we leave the meeting and we're done. But some good things, I guess I got access to a lot of opportunities that I wouldn't have"**. Bobbie went on to explain that they could interact on a one-to-one basis with mentors and teachers who might have been difficult to connect with in an in-person environment. Lo described a similar perspective, while recognizing the challenges that others may have with online learning: **"I found that in the online, like, platform, I was able to, like, really ask, like, I'm someone who's, like, more reserved in, like, a regular**

classroom environment. And I found, like, with online learning, I had more courage to like, speak up and ask questions, and especially with, like, with online school … I know a lot of people, a lot of other people, like, in their experience, they felt it was, like, disconnected, but I feel like, with online school, you have to put in, like, the effort to sort of make a connection. So, there's sort of like a disadvantage there."

Although it may be tempting for an organization to see these kinds of perspective as a ringing endorsement of shifting to online learning, thinking that it promotes greater equity due to improved ***access***, accessibility is compromised if the learner can get into the space but not learn effectively while there. Vesper explained the struggle of learning from home and the feelings of isolation that attended the online learning space: **"for me, I just really need to be in person to be engaged … I had to go through, like, a year of school and, like, that itself was just, I don't know why, but it was really, really hard to, like, transition to online classes, show up every day … then, like, when I switched to [GirlTech] ... I definitely felt, like, more lonely"**. Nova described the perspective of those who struggled to keep up with the pace of coding sessions due to Internet speed and the challenges of working in isolation (so that you could not quickly check with a person nearby): **"It was okay, just some days … the Zoom connection would just, like, drop sometimes, like randomly, and then I wouldn't get it back for, like, 15 minutes and then I'd be, like, really behind on what we were learning, right; clearly they had gone through another, like, code and they've already put it down and they're starting something new. So, sometimes in those moments I was just be like, okay, should I, like, how much effort do I have to put in to try to find, like, ask them, and like, stop everybody from continuing on and ask them if they could share their screen to the previous code so I can type it all in, right? So, oftentimes, because of those little challenges, I wasn't able to learn as well"**. This can happen when multiple tabs, windows, and/or devices are being used at once, due to the challenges of watching while practicing within the online space.

Implications and Recommendations

Below, we briefly reflect on the findings outlined above. In addition to the study's findings, we add a few contextual comments that did not fit into the themes derived above, but which have influenced the recommendations presented. The list of recommendations serves as suggestions for an informal CS program, like GirlTech, seeking to integrate equity considerations into their operational model.

We were interested to find that most of the research participants were committed to science-oriented post-secondary education and/or careers (we are aware that this may represent a selection bias for those who responded to the invitation to participate in this research). Those research participants who chose different career pathways reported gaining invaluable life skills, particularly communication skills, that could be utilized in a range of education and business contexts. Program attendees described

the self-confidence they gained through development of these skills, promoting their sense of belonging in the CS field.

We found that a number of the youth were unclear about how they learned about the existence of the GirlTech program, many describing how they stumbled across the program information by chance or by word of mouth, but they were grateful that their lives were so positively influenced by that one chance encounter. Moreover, most of the youth in GirlTech's target age group would be eligible for part-time work, making participation in daytime summer programs less appealing; this is particularly challenging for youth whose circumstances mean that they need to work during the summer. A four-week program with a potentially long commute may not be a viable option for these youth. However, we found that, despite some confusion regarding computer ownership, youth really appreciated the fact that they had full use of a high specification laptop which, had they known it was theirs to keep from the outset, may have been a strong incentive to forego potential employment for 4 weeks during the summer (the value of the laptop would certainly offset the amount gained through minimum wage work).

Overall, the participants had motivating and career-changing experiences that continued to inspire them years after completing the summer program. The positive ***experiences*** and sustained ***participation*** in CS education (through program reenrollment, scholarships, internships and other supports) are two parts of the CAPE framework that are typically difficult to achieve and maintain. The GirlTech program has illustrated some key strategies that a program can use to address all aspects of the CAPE equity framework. It has demonstrated many approaches for addressing inequities in the CS education system, especially for youth living in the intersectionality of gender and socio-economic marginalization.

Recommendations:

- We heard from a number of program attendees who discovered the program by chance. We suggest that organizations review the effectiveness of strategies to recruit potential attendees into the program. Targeting a specific cluster of schools or a defined school district (given that income status designations are ascribed to Canadian neighborhoods) and contacting schools directly, might provide support for effective dissemination of information to ensure that it reaches the desired target group. In specific reference to GirlTech, we interviewed a number of past participants who would have served as excellent advocates in the process of recruiting youth from schools in target neighborhoods.
- Many informal education providers have started offering 'stipends' to incentivize youth, who are at an age where they could be working, to attend educational programming. Many organizations have acknowledged the conceptual challenge of, effectively, paying young people to learn. So, it might be useful for organizations to consider focusing their efforts on youth in the 13-15 age bracket, given that they might be too young to work outside of the home and this

is the same age when decisions about subjects of interest and potential careers start to solidify. In the case of GirlTech, we could see program attendees starting with the kind of program described in this report, then progressing to more advanced CS skill development (as might be seen with hackathons and codefests).

- The industry link is central to the operational model of this kind of program so it might be useful to provide transportation (perhaps a school bus) for youth to travel from a defined community/neighborhood location to the offices of the industry partner.
- It might have been helpful to have clearer messaging about the use and ownership of devices provided by the organization. While it is acknowledged that precarious funding streams for non-profit organizations can result in policies changing with each iteration of a program, it might be useful for a learner to know that they will be able to use and keep a high specification laptop provided that they fulfil certain requirements (such as 80% attendance over 8 weeks of the program in consecutive years). It might be helpful to inform potential participants of the current value of the laptop so that they are able to equate that to the number of hours of minimum wage work they would need to complete to acquire the device. Under these circumstances, keeping the computer would be a given (and could represent the kind of stipend).
- Prior to starting the program, it was difficult for program attendees to know if their at-home computer and Internet provisions would be effective enough to perform the activities and practices that would benefit them within the program. We suggest that an organization devise a set of activities that the potential program attendee could use to try out capacity and functionality in their home environment before submitting their application, so that potential attendees can be clear about any additional resource needs they might have, and they can clearly articulate these at the time of application.