

# **Why a K-12 National Computer Science Education Program is Necessary in Canada**

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Nine out of ten Canadians think that it is important to learn computer science [CS] in school, yet only seven out of thirteen provinces include CS in their curricula (Sariffodeen, 2018). Many Canadians interact with technology daily and it plays a vital role in our economy. Despite its large impact, could you navigate to and open a file on your computer using only command line? For most Canadians the answer is probably no. Although some might say using command line is unnecessary, sometimes a basic knowledge of file systems and commands can help get you out of a bind with problematic software. Other than the specific use of the command line interface, CS education is beneficial in at least three ways. Firstly, CS education helps improve problem solving and critical thinking skills. Secondly, CS related industries make up a large portion of the Canadian economy and are growing quickly, therefore investing in CS education will help the economy prosper. Lastly, social and economic equity in Canada can be improved by providing equal opportunities for CS education. CS education teaches essential critical thinking skills and is valuable socially and economically in Canada, therefore the Canadian federal government needs to implement a national CS education program.

I'd like to share a short anecdote about using the command line interface in case the relevance of the previous reference of it escaped you. Last week I was helping my friend start coding. He is quite computer literate as he does plenty of research before buying electronics, plays video games and I remember him telling me about taking apart his PlayStation 5 controller to fix it not too long ago. We had installed a simple text editor for him to write code on, but we wanted to set some customized settings to maximize efficiency. To make these changes, we needed to edit the configuration file for the text editor. We found the preexisting configuration file and opened it; however, the file would not allow us to edit it.

My friend was stuck. Having a background in CS I imagined a few options to solve this problem. We could have changed the permissions associated with the file, edited the file as an administrator or created a new configuration file for the text editor. After having tried a few things and reading documentation online, it appeared the easiest option was to create another configuration file which contained extra instructions when the program was booted up. Although the task we had set out to complete was CS related, the problem was quite ordinary; we wanted to customize the default settings for a program on opening. The only reason I had insight into the problem and my technologically savvy friend did not, was due to formal CS education. Without knowledge of file systems and the command line interface the problem might have seemed intimidating, but these are common topics taught in CS. A foundational education in CS would grant every Canadian the ability to troubleshoot many everyday technology related problems.

In addition to anecdotal evidence, more formal studies have shown CS education improves problem solving skills. Undergraduate students at Stanford University conducted a “black box” experiment to analyze undergraduate student’s problem solving skills based on major (Salehi et al., 2020). The experiment involved participants making guesses about the structure of a virtual electrical circuit (Salehi et al., 2020). The circuit was obscured by a block box, but several wire leads connecting to the circuit protruded from the edges of the box (Salehi et al., 2020). Students were allowed to connect their own circuits to these leads to gather information about the circuit (Salehi et al., 2020). The three groups of majors studied were CS, quantitative natural science/engineering and all other majors (Salehi et al., 2020). The results of the experiment showed computer science majors excelled in two areas of problem solving when compared to the other two groups (Salehi et al., 2020). Firstly, CS

majors showed better comprehensive data collection skills (Salehi et al., 2020). Secondly, CS majors showed increased ability in problem decomposition (Salehi et al., 2020). Another noteworthy result was that CS majors were the only group which showed improvement for upper-year students compared to first-year students (Salehi et al., 2020). This suggests that CS courses improve problem solving skills. One may mistakenly attribute the improvement in understanding circuits to course work, however, the study highlighted that the upper-year quantitative natural science/engineering majors had similar exposure to electrical circuits as upper-year CS majors (Salehi et al., 2020). Although this study provides promising evidence that CS courses improve problem solving skills, the participants were not K-12 students and the study's sample size was small (Salehi et al., 2020). Despite the shortcomings of the Stanford study, more relevant evidence was provided in Arfé et al.'s (2020) study which focused on the effects of coding exercises on two executive functions in first graders: planning and response inhibition. The study is important because executive functions are "abilities that support individual's cognitive control, goal-directed behavior and problem solving" (Hongwanishkul, Happaney, Lee & Zelazo, 2005; Zelazo, Muller, Frye & Marcovitch, 2003, as cited in Arfé et al., 2020, p. 2) and are "foundational to children's school achievements" (Masten et al., 2012; Purpura, Schmitt & Ganley, 2017; Roebbers, Rothlisberger, Cimeli, Michel & Neuenschwander, 2011; Vandenbroucke, Verschuren & Baeyens, 2017, as cited in Arfé et al., 2020, p. 2). Arfé et al. (2020) found that first graders who participated in coding exercises for a total of eight hours had greater improvements in planning and response inhibition when compared to a control group which participated in eight hours of science, technology, engineering and math [STEM] related coursework. The study involves participants whose age is relevant to this paper and uses a larger sample size than the experiment conducted by Salehi et

al. (2020) (Arfé et al., 2020). These two studies are important because problem solving skills are not only essential for K-12 students who go into STEM related fields but also in everyday life (Wing, 2006). The problem solving skills that CS education promotes are foundational skills for a successful education system.

Technology is essential to the Canadian economy, accounts for much of the growth of the economy and offers annual salaries which are above the national average. These three factors show that investing in CS education is a worthwhile endeavor for Canadians. The information and communications technology [ICT] sector accounts for many of the CS related jobs in Canada and therefore is a good indicator of the influence that technology has on the economy.

Innovation, Science and Economic Development Canada (2021) reported that in 2020 the ICT sector accounted for 5.1% of Canada's gross domestic product [GDP]. The sector is also growing rapidly, with a compound annual growth rate of 4.2% from 2015-2020 compared to .7% for the whole economy during the same period (Innovation, Science and Economic Development Canada, 2021). Furthermore, the sector has accounted for 27% of GDP growth in Canada from 2015-2020 (Innovation, Science and Economic Development Canada, 2021).

These figures show that the sector is a vital part of the economy and is also one of the fastest growing sectors in Canada. The ICT sector also boasts salaries 46% higher than the average Canadian, demonstrating its value to the individual, not just the nation as a whole (Innovation, Science and Economic Development Canada, 2021). Lastly, the sector has proven to be a resilient part of the economy. For example, in 2020 Canada's GDP fell by 5.1%, but the ICT sector saw growth of 2.9% (Innovation, Science and Economic Development Canada, 2021). Covid-19 may have negatively affected the ICT sector less than others, however the resiliency of the sector should not be ignored. Given the economic powerhouse that the sector has

become, it would be worthwhile for the Canadian government to invest in education which promotes the sector's growth.

Computer science education also has the potential to improve social equity within Canada. This argument hinges on the underlying condition that all Canadian schools have equal access to internet and computers. Internet accessibility rates in Canada have been increasing in the last decade and as of 2018 only 6% of Canadians did not have internet access at home (Statistics Canada, 2019). Furthermore only 8% of those who did not have internet access reported internet service could not be installed, meaning less than 1% of Canadians are unable to have internet access (Statistics Canada, 2019). Even with a low proportion of people unable to get internet at home, Canada is making efforts to improve connectivity. For example, in 2021 Canada invested \$1.44 billion in Telestat to connect rural areas to internet via satellite (The Canadian Press, 2021). Assuming efforts will be made to ensure all schools have equal access to internet and computers, the favorable outcomes of CS education such as improved problem solving skills and increased opportunities to high paying jobs can help improve social and economic equity in Canada. British Columbia is one province which has implemented CS education in the curriculum and made efforts to ensure female and Indigenous students have equal opportunity to CS education (Fowler et al., 2021). If these efforts can be matched when creating a federal-level CS education program, then schools will further promote social and economic equity.

Creating a federal CS education program is a worthwhile investment in Canadians and the nation. The program would increase computer literacy, general problem solving skills, economic productivity and social and economic equity for Canadians. As the production and development of technology accelerates, the importance of having an education in computer

science will only increase. The investment made by the Canadian government will fuel the growth of the ICT sector and propel the economy forward. Canadians want computer science to be taught in schools, and most homes already have access to Internet, therefore there has never been a better time to implement a Canada-wide computer science education program.

### **Grading Reflection**

I believe I deserve about a B+ on this paper. As someone who has typically struggled a little with writing, I'm fairly happy with how this paper turned out. I worked on understanding and implementing many things which previously had escaped me as a writer including using the active voice, proper tense and clear sentence structure throughout my paper. I also tried to incorporate elements from class, specifically Paul Lynch's (2011) work *The Sixth Paragraph: A Revision of the Essay*. I included my anecdote on pages 2 and 3 and wrote in the first person and second person in the introduction and anecdote because I thought it would add relatability for my readers. I know that these are not typical elements of a research paper, but I thought they related to Lynches writings. I tried to make much of the body of my paper logical, so that the structure of my essay still built credibility as well. If I had spent more time refining my paper, I would have had more time to ask about in-text citations, since I got a little lost on one of them on page 4. I also would have appreciated asking someone knowledgeable about any issues with APA in my paper since I'm not the best with formatting.

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