How New Brunswick implemented its computer science education program

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Summary

Computer science (CS) education helps students acquire skills such as computational thinking, problem-solving, and collaboration, among others. It has been linked with higher rates of college enrollment, and (Brown & Brown, 2020; Salehi et al., 2020) a recent randomized control trial study also showed that lessons in computational thinking improved student response inhibition, planning, and coding skills (Arfé et., 2020). As these skills take pre-eminence in the rapidly changing 21st century, CS education promises to significantly enhance student preparedness for the future of work and active citizenship. CS education can also reduce skills inequality if education systems make a concerted effort to ensure that all students have equitable access to curricula that provides them with the needed breadth of skills, regardless of their gender, ethnicity, or socioeconomic status.

Based on prior analysis and expert consultation, we selected 11 country, state, and provincial CS education case studies from which we can draw lessons that may apply broadly to other education systems. These cases come from diverse global regions and circumstances and have implemented CS education programs for various periods and to different levels of success. As such, we have examined information to extract lessons that can lead to successful implementation.

This study will examine how New Brunswick seeks to improve and expand its CS education activities to train a future workforce that can thrive during economic transition and support the Canadian province's budding technology sector. The Department of Education and Early Childhood Development (DEECD) and various stakeholder organizations aim to give all students the opportunity to learn CS and apply their lessons in a creative and collaborative environment.

An overview of CS education in New Brunswick

New Brunswick's education system placed an early emphasis on CS for a period in the 1970s and 1980s that dissipated in the next decade. Then, in the early 2000s, the DEECD decided to refocus its curriculum on STEM (science,

technology, engineering, and mathematics) subjects, including ICT (information and communications technology). This brought the necessary infrastructure and knowledge of digital technologies into schools that would later set the stage for mandatory CS courses in 2017.

The DEECD faced the challenge of rolling out CS education for students of two distinct language groups. Primary school teachers in the anglophone sector were encouraged to incorporate CS and computational thinking as interdisciplinary subjects, while the francophone sector had no requirement to offer either subject in primary schools. All lower-secondary school students, whether English- or French-speaking, take CS courses that emphasize programming skills. Further, both language systems offer more advanced CS courses in upper secondary school as electives.

Organizations such as Brilliant Labs and the national flagship coding initiative CanCode familiarize K-12 students with CS through classroom and after-school activities. This enables students to apply their CS lessons during hands-on classroom lessons.

Lessons Learned

- CS education should be delivered to both the anglophone and the francophone education systems as the DEECD attempts to meet the needs of students in each language group.
- CS activities encourage students to find creative and practical uses of digital technologies that can spark an interest in CS. In particular, makerspaces—customizable learning spaces that allow students to develop their own projects—have created an interactive and collaborative environment that have produced positive learning outcomes.
- The DEECD works closely with NGO partners, leaning on their resources to engage students. This includes providing after-school programs, summer camps, and even activities with CS integrated as an interdisciplinary subject.
- Teachers can use communities of practice to share information about helping students from different backgrounds learn about CS.

Motivation for CS education

New Brunswick has made a name for itself as a low-cost hub for both local and international technology companies' nearshore operations. The province's low cost of living and geographical proximity to the United States have attracted a variety of multinational companies such as IBM, Salesforce.com, HCL Technologies, Xerox, and Hinduja Global Solutions (Robicheau, 2019; Austen, 2004). New Brunswick has also turned into a national leader in cybersecurity by becoming the first province to launch a comprehensive cybersecurity strategy in partnership with IBM, University of New Brunswick, and Opportunities NB—the province's leading economic development group (Robicheau, 2019). Given these developments, demand for CS professionals in the province has grown significantly over the last two decades.

Despite the proliferation of its technology sector, New Brunswick has an aging population that hampers its ability to attract enough talent to fill its technology-related job openings (Government of New Brunswick, 2013). As the current workforce ages and retires at a high rate, the province expects about 12,000 annual job openings between 2018 and 2027 (Government of New Brunswick, 2019). Due in part to the high number of unfilled vacancies, New Brunswick's unemployment rate of 8 percent exceeded the national unemployment rate by over two percentage points (Government of Canada, 2020), and a recent analysis of the labor market in the province found a skills mismatch between employers and jobseekers (Government of New Brunswick, 2019). Given the need to develop a labor force that meets the demands of its modern economy, New Brunswick has a strong incentive to train its K-12 students in computational thinking and CS.

Origins of CS education

CS education in New Brunswick traces its origins back to the 1970s, when Canada included programming in its mathematics curriculum (Freiman, 2017). In that time, New Brunswick francophone students even learned how to construct algorithms using the BASIC programming language as early as primary school. Yet, reforms in the 1990s and early 2000s removed programming from the primary school curriculum and replaced it with computer literacy (Freiman, 2017).

The province renewed its interest in CS education in 2013 when David Alston, former vice president of the New Brunswick-based social media tracking company Radian6, started advocating for the inclusion of coding in the K-12 curriculum (Harrop, 2016; Kimber, 2018). Alston and Rene Boudreau, then an executive of New Brunswick's Council on Research and Innovation, advocated for their cause to provincial government officials, and succeeded in 2014 when Premier David Alward announced the launch of a new organization called Brilliant Labs that would go on to lead CS education in the province (described in detail below). One year later, Alward's successor, Brian Gallant, appointed Alston as New Brunswick's first "entrepreneur-in-residence," a voluntary position to leverage Alston's experience and "foster innovation, inside and outside of government" (Kimber, 2018).

The DEECD took several steps over the next few years to bring CS into its curriculum. First, it piloted programming lessons in 2016 as one of the three subject areas in its Middle School Technology course, along with Computer Operations and Project Work (DEECD, 2016). In this course, teachers had the flexibility to adjust coursework and expand the curriculum beyond computer literacy—e.g., creating folders, saving work, and developing presentations. Then, in 2017, it made programming education mandatory for grades 6-8 as part of the Middle School Technology Education curriculum (Julie, 2017). In the same year, DEECD began to require that high schools offer two specialized CS courses targeted to students with a vocational interest in CS or an intent to pursue the subject as an undergraduate major (Julie, 2017).

Civil society's role in supporting CS education

Several nonprofit organizations have worked with schools to deliver creative teaching and learning opportunities including after-school programs, summer camps, and even activities with CS integrated as an interdisciplinary subject. Most notably, Brilliant Labs supports teachers and students inside and outside of school. Brilliant Labs provides learning materials to schools so they can offer students CS lessons using makerspaces—learning spaces with customizable layouts and materials that encourage students to develop projects, engage with technology, learn, and collaborate. These makerspaces enable students to creatively apply their CS and computational thinking lessons, sparking interest and deepening understanding of CS and computational thinking. The organization has now supported over 2,374 events and coding workshops in the province.

In addition to supplying the needed materials for these spaces, Brilliant Labs supports in-class lessons and professional development for teachers, including communities of practice for CS educators around the province. Survey evidence suggests that teachers who oversee makerspace activities expressed a "desire to change their teaching." The instructors also report that they learned to encourage students to take the lead in projects through trial-and-error (Freiman, 2020).

Besides supporting makerspaces, Brilliant Labs runs multiple student engagement programs. For example, it hosts weekly after-school coding sessions that are based on drag-and-drop technology, like Scratch, but can also include more advanced activities for older and more advanced students ("Coding classes designed to create future entrepreneurs", 2014). Additionally, the organization runs summer camps throughout the province that reach 8,500 students per year. Given these opportunities, more students have a chance to develop an interest in CS and apply their in-class lessons to their own creative projects.

Though Brilliant Labs may have the largest footprint of civil society organizations in New Brunswick, other organizations play important roles. The central Canadian government's flagship coding initiative, CanCode, has funded several initiatives that have reached New Brunswick students. One of these initiatives, Youth Fusion, assigns university students to public schools to teach topics such as artificial intelligence, video game design, and robotics. Other initiatives such as COVE and Science East Science Centre have enabled students and teachers to connect CS to other sciences for a more engaging learning experience. For example, COVE leads the Ocean Summer Institute and Participatory Design Conference, which trains teachers to apply digital and mechanical ocean technologies such as dataloggers or marine turbine kits in their classrooms. This interdisciplinary setting exposes students to CS who may not have had a chance to become interested had they not participated.

CS course development and curriculum

New Brunswick became Canada's first official bilingual province under the 1969 Official Languages Act that paved the way for French immersion in the provincial education system as part of a national push toward equal access to services. This necessitated dividing the education system into anglophone (English speaking) and francophone (French-speaking) sectors, both creating their own curriculum in 1977 (Rogers, 2017). Today, CS education differs by language sector in primary school, but all secondary school students have the same CS learning opportunities.

Throughout each grade level, New Brunswick students have opportunities to learn CS through traditional pedagogies and then apply lessons by finding practical uses for digital technologies. Consistent with the vision of makerspace activities, the curriculum emphasizes that teachers have the freedom to tailor lessons for different groups of students to foster a more immersive learning experience that can encourage all students to deepen their understanding and develop an interest in CS.

At the primary level in English-speaking schools, teachers are encouraged to make programming a key learning goal by integrating coding skills in their lessons whenever possible (Blanch, 2017). French-speaking schools, however, do not have the same mandate to teach coding or computational thinking at the primary level.

Students in grades 6 through 8 of both the anglophone and francophone sectors have had a requirement to learn CS since 2017 (Blanch, 2017). This lower secondary school curriculum calls for students to learn how to innovate, prototype, and evaluate products so that they can understand principles of entrepreneurship and design elements. To this end, the technology course offers instruction in app development, robotics, game development, and electronics. Further, students learn about the importance of responsible digital citizenship, as well as the dangers of cyberbullying, phishing, and malware (DEECD, 2016). Though the DEECD mandates this framework, it also encourages schools and teachers to tailor lesson plans according to their students' needs.

At the upper secondary school level, both language sectors must offer two CS courses as electives to students from grades nine to twelve (Julie, 2017; Blanch, 2017). Both of these courses, Computer Science 110 and Computer Science 120, include programming through project-based learning. Computer Science 120 builds on the content that students learn in Computer Science 110 and introduces advanced concepts in computer usage and applications (DEECD, n.d.).

CS education inclusion

Facing apparent disparities in interest among groups of students, the DEECD runs programs to engage students from underserved communities in CS education. Survey results and university enrollment data indicate that opportunities to learn CS are unequal between genders in New Brunswick. In a 2018 survey of Canadian teenagers, more than 70% of respondents of both genders believed that it was "extremely or very important" to learn about CS. Yet, boys were twice as likely to respond that they were "extremely" or "very"

interested in pursuing CS careers (Silcoff, 2018). Though the survey does not report results at the provincial level, university-level data indicate that New Brunswick is likely no exception to the Canada-wide trend. University of New Brunswick professor of CS Andrew McAllister noted in 2015, the last year the data were reported, that only 77 of the 530 students in his undergraduate class were women ("UNB professor says fewer women enrolling in computer science," 2015).

Recognizing this disparity, the DEECD has taken steps to make their CS education activities more inclusive. The DEECD encourages high school CS teachers to use different learning pathways for students of diverse backgrounds and learning styles. The Universal Design for Learning (UDL), a professional learning community, offers teachers pedagogical flexibility through various materials and teaching strategies to help create an inclusive learning environment in CS classes (DEECD, 2019). The DEECD also explicitly instructs secondary school teachers in its CS curriculum guide to "recognize and honour" their students' experiences and cultures. The curriculum guide encourages teachers to view the world in a more holistic way by teaching CS in a practical context through active participation and oral communication. It also instructs teachers to consider other cultural variations such as geographic (urban versus rural) and immigrant status so that teachers can adjust classroom activities.

Conclusion

New Brunswick has made substantial progress expanding and improving CS activities in its education system. The anglophone and francophone curricula address CS education differently in that only the anglophone primary curricula includes computational skills. However, both systems are required to enroll students in a CS course in lower-secondary school and offer CS elective courses in upper-secondary school. While students still face disparities based on factors such as gender, the provincial government encourages teachers to learn how to address all students' needs.

New Brunswick education authorities work closely with stakeholder organizations to make CS more interesting to all students. The use of makerspaces—customizable learning spaces that allow students to develop their own projects—has created an interactive and collaborative environment that have produced positive learning outcomes. These kinds of initiatives function alongside the province's core curriculum to help students develop critical thinking and problem-solving skills.

The DEECD and its nonprofit partners use student engagement activities like after-school programs and summer camps to extend CS instruction to students who would otherwise have few opportunities to become interested in the subject. The DEECD has also set up communities of practice to support teachers who try to make CS lessons more effective for underserved students.

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