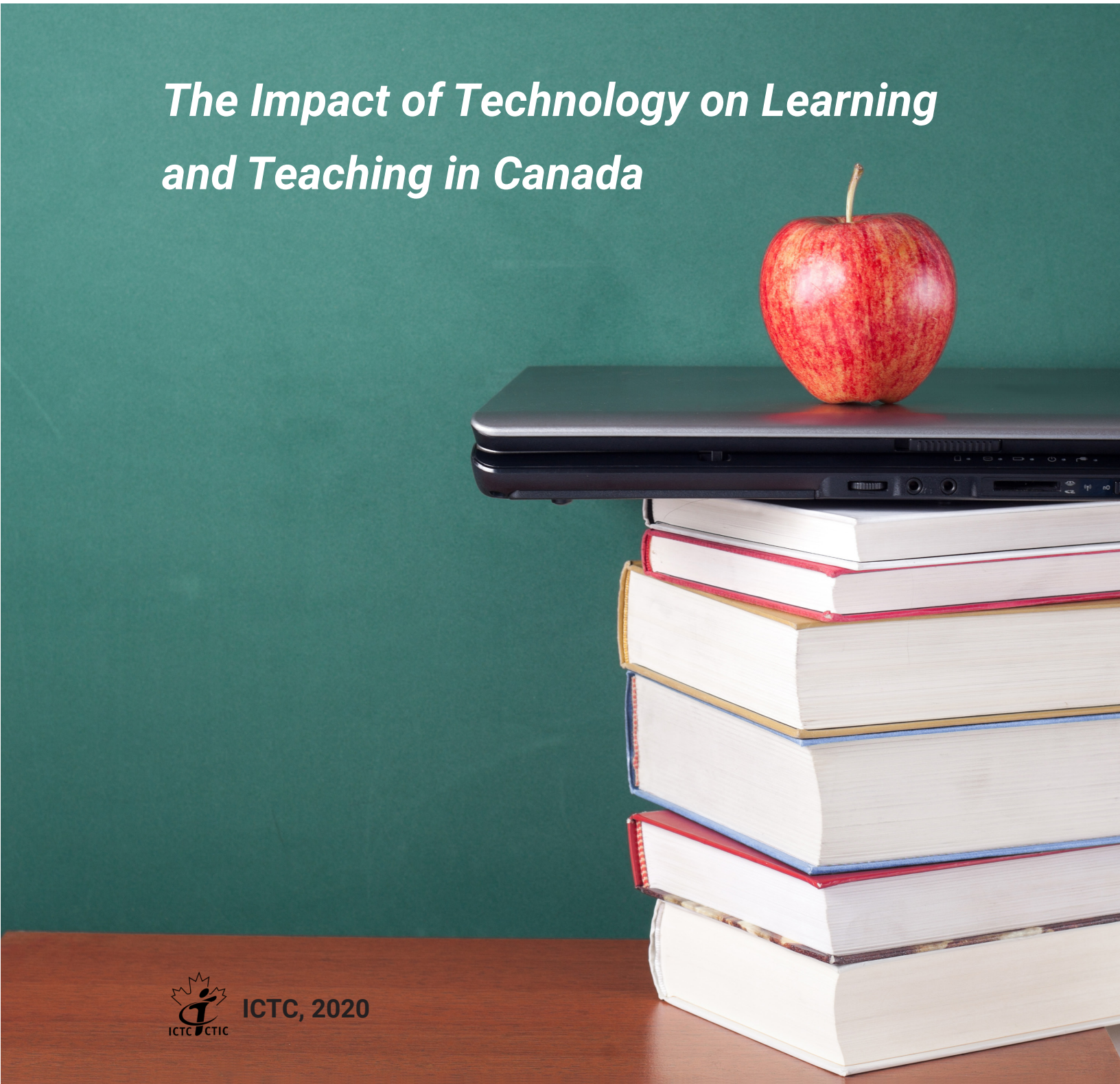
CLASS, TAKE OUT YOUR TABLETS

The Impact of Technology on Learning and Teaching in Canada



ICTC, 2020

Preface:

As a not-for-profit, national center of expertise, ICTC strengthens Canada's digital advantage in a global economy. Through trusted research, practical policy advice, and creative capacity-building programs, ICTC fosters globally competitive Canadian industries enabled by innovative and diverse digital talent. In partnership with a vast network of industry leaders, academic partners, and policy makers from across Canada, ICTC has empowered a robust and inclusive digital economy for over 25 years.

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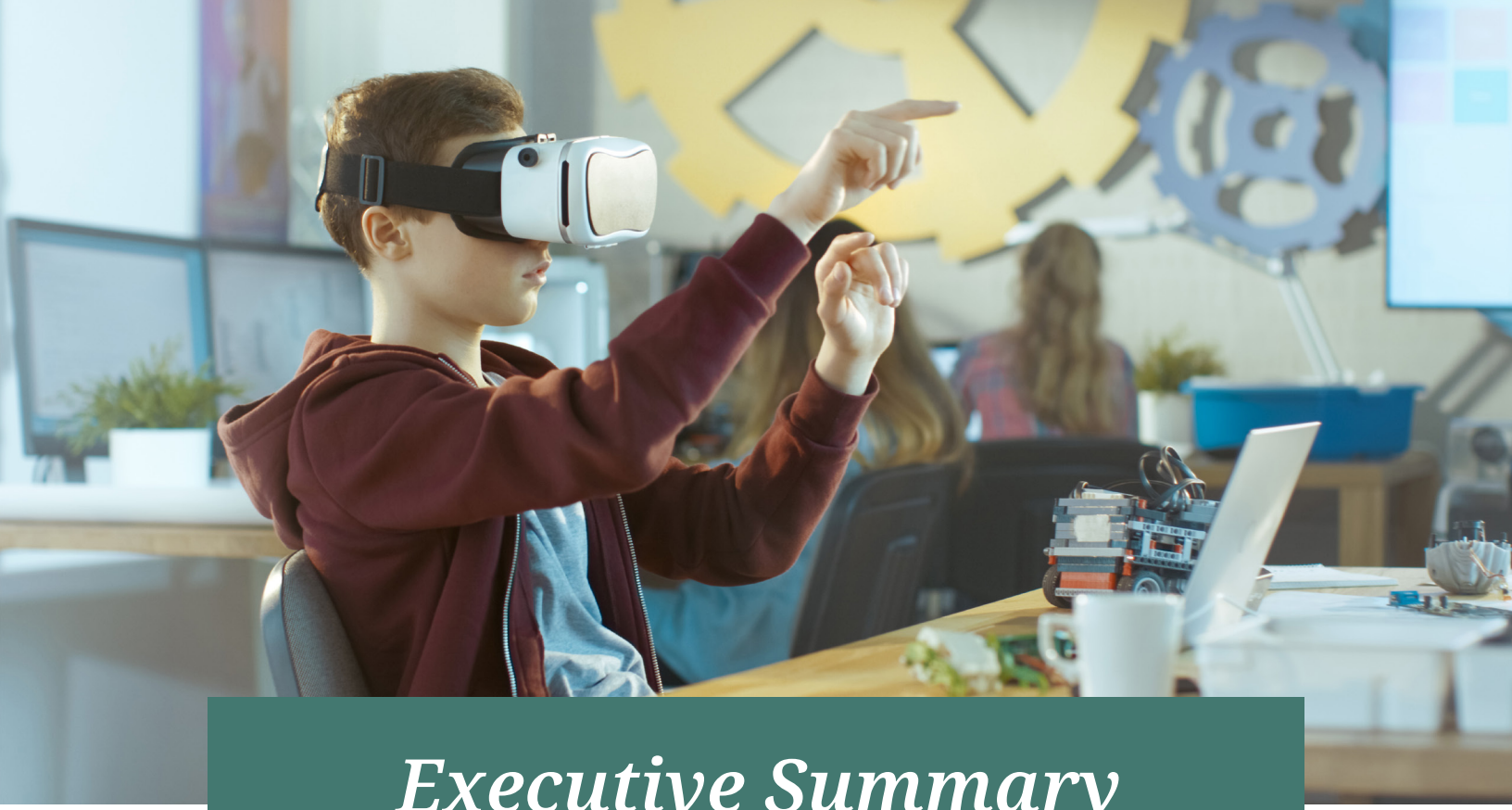


Executive Summary

With rapid and scaling digitization, **the classroom is increasingly a place where technology and traditional education methods collide**. Digital knowledge and skills will continue to be critical as Canadian educators incorporate emerging technologies to aid student learning and accessibility, and to engage and inspire a new generation of future leaders. This new landscape is ripe with opportunity, but the challenge remains to better understand the intersection between these developments and evolving student learning experiences. This study evaluates the increased presence and role of technology in the classroom. Assessing benefits, challenges and future opportunities, this study explores emerging educational technologies, highlights how these digital developments can be leveraged to solve problems, and ultimately how they enhance the student learning experience.

Anchored in a series of insights derived from more than sixteen key informant interviews, this research also showcases the attitudes and insights of educators toward the growing adoption of hardware and software in the K-12 Canadian education system. **Accessibility, equity, diversity, connectivity, and teacher training and support were recognized as foundational concepts for largescale implementation of technology in the classroom. Collaboration and partnership between academic institutions and industry, and effective procurement policies for digital tools are pathways for the effective implementation of technology.**

Given the challenges and complexities of navigating the Canadian K-12 education system, stakeholder engagement will be crucial to ensuring coordinated efforts. Future efforts must involve policymakers, school districts, educators, parents, Indigenous communities, technology providers, and the general public to address the following issues in emerging education technology:

- training educators in the use of technology
- effectively integrating technology into the classroom
- addressing challenges of insufficient broadband connectivity
- recognizing unique cultural needs for local communities
- managing technology-related distractions
- assessing learning outcomes and new skills development
- ensuring student data privacy protections

Technology is becoming the fabric of our daily lives and the classroom is no exception. New and transformative technologies like artificial intelligence (AI), Augmented Reality/ Virtual Reality (AR/VR), and many others are rapidly changing our economy and providing new opportunities on a global scale. **Regardless of the method of administration, the blending of technology and education has been found to help students achieve better educational outcomes while also expanding their interest in subjects such as computer science, interactive digital media, and cultural preservation.**

The demand for talent in Canada's digital economy is expected to reach approximately 305,000 by 2023.[1] Critical areas include data science, user experience design, software development and many other technology roles. But the core skills of this demand are agility, teamwork, flexibility, and the need for lifelong learning. **Tech-integrated education changes and amplifies student learning by providing the interactions that can shape their future educational journey and encourage new ways of thinking. By developing these foundational concepts from an early age, technology in the classroom is key to equipping students for success in a rapidly expanding digital economy.**

Introduction

Technology is transforming the day-to-day life of Canadians and, particularly, of the younger generation. While not without its challenges, the implementation of technology in the Kindergarten to Grade 12 (K-12) classroom is now providing unparalleled learning opportunities that were not available to previous generations.

Given the structural transformation of the Canadian and global economy, the nature of work itself is also evolving. New ways of working in the sharing and gig economy, the advent of transformative technologies such as AI, Blockchain and others are driving this new reality. In the coming years, it is likely that Canada's new generation of talent will graduate and be employed outside of traditional 9-to-5/Monday-to-Friday work hours. Many of these new jobs will require some degree of digital competency. **By better understanding and leveraging non-traditional pedagogical approaches, including the integration of technology, Canada can adapt, and educators can better train youth for continuous learning in an ever-changing environment. This will be key for building necessary skills like adaptability and flexibility, which are essential to effectively engaging in the future economy**.

With technology playing such an essential role in this transition, **educating youth to be more than mere users of technology is a must**. This entails leveraging a wide range of tools that vary from basic design thinking or logic-based platforms to gamification and even AR/VR to create individual, modular, adaptive, and scalable learning opportunities that will benefit them through life. The research contained in this study is derived from a series of key informant interviews (KIIs) conducted with educators and education experts (K-12 and post-secondary) across Canada. It includes a robust analysis of existing literature, data and international case studies. Combined, this study showcases the impact of technology on student education and highlights the building blocks needed to make this a positive journey for both students and educators.

Tech in the Classroom: How is it Perceived?

Before addressing the types of technology needed, it is important to first understand general attitudes toward technology its potential role in education. To do so, ICTC provided the following two statements to the experts interviewed for this study and asked whether they agreed or disagreed with each (other questions were posed later in the interviews, but these initial statements gauged **immediate attitudes or beliefs related to technology in the classroom**).

***Yes or No:* Technology can enhance education, make learning more fun as well as more effective.**

This question received an overall positive response, with nine out of fifteen interviewees (60%) agreeing with the statement. Three other interviewees also agreed but added qualifications or caveats. For example, one agreed with the statement *if* it also meant intentionality of design for the integration, while another agreed but felt that there may be instances where this would not be the case. Although none of the participants outright disagreed with the statement, three participants were neither in favour nor against it.

***Yes or No*: Technology in the classroom is a must-have if students want to be prepared for almost any career today.**

Twelve of fifteen (80%) interviewees agreed with this statement. **Most educators believed that technology would continue to grow in importance for different careers, *including ones that have not traditionally required it*. Two other participants expressed concerns over the extent to which technology should be integrated in the classroom (although they did not dismiss the need for technology in education, they believed that it does not necessarily need to be used in *every class*)**. Lastly, one interviewee disagreed with the statement altogether, showcasing concern over the extent to which students may be overly pressured to follow technology career pathways. This interviewee noted that while technology may be a *component* of many jobs, technology-based careers may not be the right fit for all students.

Despite mixed sentiments about the ability of technology to holistically enhance education, Canadian educators interviewed expressed the belief that technology use and digital skills would provide students with the opportunity to gain better knowledge of future career needs. **Areas specifically highlighted by educators were digital citizenship, responsible internet usage (and internet risks), permanence of digital data, and ethics**. By using technological tools and gaining new digital skills, students would not only produce better immediate learning results (i.e. improved test scores) but could also cultivate their skills in new and emerging areas that will see demand in the future economy.

Impact on Student Learning:

How Tech in the Classroom Trains Students to Think Differently

Several studies have highlighted the potential benefits of technology use in education, with some even suggesting a few technologies in particular that have the ability to enhance a student's overall knowledge and skills.[2] The traditional teaching model, based on active instruction by a teacher and passive reception of knowledge from a student, does not necessarily still allow students to develop many 21st century skills needed to be successful in an increasingly tech-based economy.[3] In today's digital economy, such a traditional model leaves fewer opportunities for students to be engaged, spark innovation, develop creativity, or learn to collaborate with fellow students to solve complex problems.

The integration of technology in the classroom enables new forms of learning that are more interactive and collaborative than previously available. A simple and commonly used example of this is 'multimedia learning.' Multimedia learning occurs in instances where listening to an instructor discuss a research project is combined with watching the result of the research displayed on a screen. Integrating multimedia presentations into lesson materials has proven to greatly increase a student's retention of course material.[4] Another example is the implementation of comprehensive reading program models that integrate computer-assisted instruction with other activities. Students that have used these models experienced significant improvements in reading scores, compared to peers who were taught without this assistance.[5]

Newly developing or transformative technologies like Augmented Reality (AR) are also increasingly playing a role in education. AR allows students in a classroom to learn about other regions of the country or other parts of the world, from their seats. They can follow the virtual expedition of a team of scientists in Madagascar, where they can learn about new plant-life, animals and explore different cultures. AR can also turn a classroom into the cosmos, helping students understand how our solar system operates.[6] This knowledge can then be applied to a collaborative group project using cloud-based apps to highlight and present key findings. While these are some examples of technology's practical application in the classroom, **the *experiences* it can provide—such as virtually witnessing endangered species of plant life in Madagascar—can ultimately change the way students think, engage with the world, and tackle problems.**

An increasing number of educators are moving beyond simple measurements of learning outcomes based on test scores and looking to assess less tangible measurements like student engagement, classroom interactions, teamwork, critical thinking and problem solving.[7] These skills are essential in a future that is increasingly digital, interconnected and diverse. While technology does not result in effective teaching and learning, it is a useful tool that can reshape the way students learn, develop and grow.[8]

Challenges of Technology in the Education System

When it comes to possible adverse effects of technology use in the classroom, studies have focused primarily on students' capacity to multitask. Because technology innately encourages multitasking, **the presence of personal electronic devices is often cited as a possible distraction**. With anecdotes such as "technology is a learning distraction, thereby hindering learning" seeing significant debate, many educators are looking for guidance around how technology can be used and managed effectively in the classroom.

When taking into account the opportunities and freedom that the internet provides,[9] the possibility of "off-task" or distracted behaviour is inevitable. Too much digital exposure, especially on devices that allow access to gaming, texting and social media can undoubtedly harm overall academic performance. A recent report from the Organization for Economic Cooperation and Development (OECD) stated that technology has mixed impact on education, with the **potential for distraction if not used and implemented properly at school**.[10] Here lies the essence of the challenge: ***How can educators effectively integrate technology in the classroom and train students to leverage it as a critical learning tool?*** This question will be investigated throughout this study.

Methods of Integrating Technology in the Classroom: Providing Students with the Tools They Need to Succeed

One-to-One Projects

There are a number of ways in which technology can be integrated into the daily teaching practices of educators. **The first is participation in 'one-to-one' projects, wherein each student is given a digital device.** In such instances, students are provided individual access to a dedicated device rather than sharing it with classmates, or being required to source their own. **Although costly in the absence of effective procurement policies, one-to-one projects have been demonstrated to yield notable improvements on overall student motivation and engagement in learning**.[11]

According to a recent meta-analysis, incorporation of **one-to-one education principles in elementary and secondary schools have shown particularly significant impacts in subjects like English, writing, mathematics, and science.**[12] **Moreover, one-to-one initiatives have proven to be useful for lower-income students, helping them feel included while gaining digital fluency or literacy skills that they may otherwise have limited access to**. Highlighting this point, a study of three schools in California showed that lower-income youth demonstrated significant gains from such initiatives—moreso than students who already had access to their own devices.

Bring Your Own Device (BYOD)

Another common method of integrating technology in the classroom is the Bring Your Own Device (BYOD) practice. Utilized by some Canadian schools to increase access to technology without having to incur the cost of purchasing devices for each student, BYOD encourages students to bring their own smartphones, tablets, or laptops to school and work with them as needed. Student devices are used to create presentations, podcasts, interactive maps, graphic designs, engage in video conferences, and collaborate with peers and teachers. A 2019 study completed by People for Education showed that **62% of elementary and 74% of secondary schools in Ontario encourage BYOD in some way**, whether for specific classes, on certain days, or for all students without restriction. [13]

The practice of BYOD offers many new learning opportunities and benefits. A recent eight-month pilot launched by the Alberta Ministry of Education studying the effectiveness of BYOD on educators concluded that, overall, **[BYOD] enhanced student performance and made it easier for educators to interact with students**. **Teachers also reported that students who used their own devices were more engaged and invested in their learning**.[14] Other benefits of BYOD include providing students with access to extended learning opportunities by using the same device at school and at home. While not without its challenges, **BYOD also allows school technology investments to be redirected to areas like the improvement of internet speed or the provision of technological capabilities like high-end video editing and new software or tools.**[15] **Lastly, BYOD can prove extremely helpful for students with disabilities, who are empowered to use their existing assistive technologies to access learning resources in a comfortable and inclusive manner.**

With all its benefits, there are also drawbacks to the BYOD practice. The primary concern, similar to that generally related to the use of tech in the classroom, is that devices can be distracting when students use them to access non-school-related material during instructional time. An additional challenge exists when it comes to integrating multiple operating systems, which can lead to roadblocks in tech support or troubleshooting for teachers. **Lastly, and most importantly, are the financial barriers or socioeconomic inequalities that BYOD can make evident in the classroom**. **Since not every family has the financial means to purchase the most up-to-date learning devices, revealing these distinctions can result in challenges at school, or create financial stresses on families.**

The Current State of Technology in the Classroom

Snapshot: Chromebooks in Schools

Chromebooks are essentially laptops that use Google's Chrome Operating System (OS). A Chromebook is designed to be used with an internet connection, as most of the applications and data reside in the cloud (accessed by the Chrome web browser). [16] The Google integration and cloud-based nature of these devices are its defining characteristic.

Advantages and Growing Popularity

There are several factors that contribute to the growing popularity of Chromebooks in the classroom. One is their similarity in physical form to pre-existing laptops. This, along with their similarity of design and functionality to laptops, makes teachers, in some cases, more comfortable with them than tablets.[17]

Secondly, the nature of the device (Google cloud-based) implies a seamless integration with the Google classroom suite of software. This is something that can reduce the number of steps required to collect or administrate work.[18] **Having data automatically stored in the cloud was also noted as beneficial for students as they can sign on from any device to access their work.**

Viewing this broadly, a Canadian research study found numerous benefits associated with Chromebooks, including its stable and durable software and the opportunities they can provide for continuous learning specific to different learning needs and styles.[19] **Valued at approximately $250 per device, the low cost of Chromebooks has been a crucial factor in allowing large-scale adoption,** especially for schools that ascribe to the 'one-to-one' practice.[20] As one study states, "When you're trying to provision 32,000 [devices], price is key."[21]

Challenges and Other Considerations

While there are many benefits that have driven the popularity of Chromebooks in education, there are also a few key challenges to consider. **The web-based nature of the devices means that Chromebooks (or other technological devices) require sufficient and reliable internet connectivity; without this, students cannot take advantage of the built-in cloud-based operating systems.**

Concerns around privacy and data usage are also emerging in relation to this kind of technology. **This concern is especially heightened in recent years with the growth of targeted marketing and new uses of mass data**. Moreover, the widespread adoption and commonplace nature of technology has also led to growing sentiments that students and their parents cannot *truly* opt out of using these devices due to a lack of reasonable alternatives.[22]

Lastly, school investments by technology companies provide long-term benefits of guiding young users toward specific brands and building user loyalty.[23] Because of this, many have raised **questions about whether the integration of technology in the classroom is more about providing students with necessary training or about forming positive and powerful brand associations among young consumers**.[24]

Snapshot: iPads in Quebec Classrooms

As early as 2013, Quebec has been investigating the educational use of iPads. Working with 6,057 students and 302 teachers, one study aimed to understand both the benefits and challenges of putting these devices in schools. With benefits outweighing the drawbacks, the study found that **incorporating the tablets into classroom education was a necessary risk, given their high cognitive potential** (mental capability involving reasoning, problem solving, planning, abstract thinking).[25] **However, to ensure a smooth transition, educators must receive sufficient training to manage the implementation process**. When rolled out and used appropriately, iPads have proven to be extremely effective in the educational space.

"I'm using iPads with my students for research. They just did a project on a career …[it] was a written production [followed by] an oral presentation. They had to find out things like, what kind of education and skills are needed as well as salary.... and they were able to use their iPads. As the class was English as a Second Language, [the iPad] allowed them to use an online dictionary as well as Google Translate."

There are significant benefits to incorporating iPads in the classroom. While greater access to a variety of resources and the development of basic digital skills is a clear advantage, **iPads in the classroom have been proven to increase motivation levels and build critical foundational skills like collaboration, teamwork, agility and creativity**. In their Digital Action Plan,[26] the Quebec's Ministère de l'Éducation et de l'Enseignement Supérieur highlights the goal of becoming a global leader in digital skills and educational practices to better prepare modern learners. This mandate specifically encourages the integration and use of technologies to foster a higher rate of success among Quebec learners and underlines the importance of iPads and related technologies that support this vision.[27]

"[In Quebec] I think what is happening already with iPads will continue to grow… I think a lot of Apple applications that are not necessarily designed for the classroom are becoming popular as well. Like GarageBand, we've been using it in [music] class. Another colleague is doing stop motion with our students and she's using GarageBand to go with that. I think we're finding [tools] that are not designed necessarily for the classroom but can be used in unique and educational ways."

Like many technological tools, the potential of distraction or off-task behaviour exists with iPads. One of the greatest challenges associated with these products is also ultimately cost. Although Apple offers competitive pricing at all school levels (K-12 and beyond), an iPad may still cost upwards of $400. Although this is less than half the market rate, effective procurement policies that partner educational institutions with technology providers is key. This kind of collaboration can better support educational institutions on their journey of acquiring the technology that modern-day students need to succeed. Despite these concerns and increased competition, Apple's iPad remains the leading device for classroom education worldwide.[28]

Snapshot: Sphero

The Spero line of products brings together physical robotics, application platforms, and coding experiences for new kinds of learning in the educational setting. One of the best-known products from this line is the SPRK robot (Students, Parents, Robots and Kids). The SPRK robot is designed to introduce coding and robotic concepts to a wide audience. It easily connects to smartphones or tablets via Bluetooth to send and receive instructions. These devices include motors (for movement in all directions as well as the ability to jump), lights, and can follow commands from users via basic coding. In the classroom, students are engaged by issuing commands from their smart devices to the robot, which can be incorporated into educational games or projects.

The Spero SPRK products utilize a C-based language called OVAL, which can be understood by young students. It does not require prior coding experience and begins the educational process slowly by using a drag-and-drop process to control functionality, including speed, direction, and colour changes.[29] One of its design strengths is the flexibility of the device to cater to different audiences, from novice coders to high school computer science students. Young students can use simple drag-and-drop balloon commands to make their Sphero bot move, however, by swiping on a button they can also see some of the raw computer syntax that exists behind the commands. While still rudimentary, this functionality is critical, as it introduces the concept of transparency and explainability related to technology from an early age and can further facilitate lifelong, effective learning in this discipline. For example, the balloon command "Set heading 178 degrees" reveals itself to be "ControlSystemTargetYaw = 178" in OVAL.[30]

Technology-inspired Education: Surrey Central Elementary School's 5th grade tech whizzes

In 2018, ICTC attended a launch for the federally supported CanCode program, hosted by a fifth-grade class at Surrey Central Elementary in British Columbia. At this school, students begin to code as early as kindergarten. By the fifth grade, they already possessed significant knowledge of coding and robotics. As witnessed by ICTC directly, students in this class were proficient with the Sphero bot, using it to build maps and programming it to take certain actions or steps. They used other applications like Bloxels to build their own video game platforms. These tools were used inclusively and enthusiastically by both the girls and boys.

Many benefits have led to the adoption of the Sphero line of products as appropriate technology devices for education: the hardware is robust (water and drop resistant), which is crucial in a classroom setting; its clear casing displays internal parts (such as gyroscopes, motors, and accelerometers), which helps engage students and encourages "tinkering" or troubleshooting; and the software integrates with mobile platforms, making it easier to control the experience.

For educators, many have highlighted the suitability of these products outside of robotics or computer-based courses. They can be used to demonstrate concepts or principles in a wide variety of areas including, but not limited to, the following:

- Math—introducing the concept of angles, speeds, measurements (time, distance, mean, median, modes through data analysis);
- Geography—highlighting latitude and longitude, navigating/mapping through a 'Battleship' game;

- Language—linking design with storytelling, teaching students to "navigate" through narrative with the robot as a moving character or perspective within an environment;
- Art—using code to create shapes and images (running the Sphero through paint, for example).

In Canada, there is increasing interest in the use of these products for educational purposes. Many school districts, particularly those in British Columbia, are examining this area and providing educational resources for teachers who may be interested.

Snapshot: Raspberry Pi

Another popular application of technology in the classroom is Raspberry Pi. A credit card-sized computer that plugs into a TV or display, Raspberry Pi can be used by students of all ages to learn basic coding and gain an understanding of electronics. Ranging from $25 to $55 per unit, Raspberry Pi is a low-cost computer running on an open-source system that was built for the purpose of encouraging access to education and engagement with technology from an early age. **Raspberry Pi is effective in training students how to use technology, while also teaching them to view it as inherently tied to their everyday lives and capable of solving practical problems.**

Examples of projects that learners have undertaken using Raspberry Pi include the following:

- Using the pi-hole to block ads on the computer;
- Creating a Twitter bot with Python;
- Creating a WordPress page;
- Creating a "traffic light" game with LEDs;
- Using the Sense HAT add-on to create an augmented reality display capable of undertaking science experiments, creating video games, etc.

Developed by the UK-based Raspberry Pi Foundation, the goal of this technology is to provide access to computing and digital technology to students around the world. To date, Raspberry Pi is used in classrooms in Canada and the United States, Europe, and even rural Africa. As of 2017, the Centre Informatique de Kuma ran two Raspberry Pi labs at schools in Togo,[31] providing critical digital education to students that did not previously have access to it.

Snapshot: Emerging Technology Opportunities in Virtual Reality/ Augmented Reality (VR/AR)

Virtual Reality and Augmented Reality are technologies with significant potential in education. VR technology uses headsets to generate a simulated image or environment that can be explored or interacted with. It can utilize expensive, high-end devices or can be modified to use simple hardware (or even integrate smartphones as a display headset). Conversely, AR superimposes a computer-generated display on a user's view of the world. This can be achieved with either a dedicated headset or with a smartphone; the mobile game Pokémon Go is a well-known example of AR technology at work. In education, AR storybooks were found to produce positive results in recall, as well as reading comprehension. AR storybooks can also help students who are less able to comprehend text-based materials, while the physical movement component of the technology can assist with engagement of students with ADHD. With growing popularity outside of the gaming world—and especially in education—**current estimates forecast that more than 15% of U.S. schools will have a VR class kit by 2021.**[32]

Recent research has highlighted the benefits of student participation, engagement, teamwork and collaboration using AR educational games.[33] **AR is particularly effective in allowing students to visualize information and concepts in new ways, including hands-on exploration of objects with superimposed virtual images**. One example of this is superimposing virtual images of the digestive system over a blank torso. **AR can shift the classroom into a more interactive lab setting,[34] providing students a variety of new skills while, ultimately, changing the way they interact with the world and solve problems**.

VR technology is another development that offers the potential to reshape education for the better. A recent study by Nature Biotechnology found a "76% increase in learning outcomes when student[s] used a [VR-enabled] gamified lab simulation ... and a 101% increase when they used it in combination with traditional teaching methods."[35] Similar to AR, VR has the power to create excitement and engagement where traditional learning tools like textbooks or worksheets fall short.

"We use VR technology to go inside a volcano and learn about the different parts of a volcano… a lot of community schools can't travel that far, it's very expensive... VR really facilitates learning."

Other applications for these immersive visualization technologies include the ability to help students who face challenges with sensory-based experiences, anxiety, or maintaining attention.[36] These technologies can also be used to develop empathy and better understanding of other cultures or relevant global realities. **For example, schools can use**

VR to show its students the living conditions of refugees fleeing Syria.[37] By providing this first-hand glimpse into the lives of people experiencing this reality—many of whom are children themselves—this technology allows students to better understand and interpret this international crisis, and ultimately become more engaged global citizens. This is only one example, but this technology can be applied to a variety of global challenges and events, ranging from elections, to climate change.

Snapshot: AI in Education – Smart Education to Virtual Facilitators, and Beyond

To a degree, educational tools like Sphero utilize automation and machine learning, both subsets of AI. Increasingly impacting the education space, AI can be used for anything from simplifying administrative tasks for educators, to altering educational resources, to assisting teachers with assessments and lesson plans. While many of these possibilities are still in development and testing stages, even three years ago in 2017, it was estimated that by 2021 the role of AI tools in U.S. education would increase by nearly 50%.[38] Although the opportunities and challenges are numerous, the following represent a few interesting and currently applied use cases of AI in the classroom.

Smart Content

Generally speaking, smart content is personalized or customized content that updates and refreshes on the basis of individual viewers' interactions with it. In essence, smart content takes into account behavioural data, contextual data, and demographic data of users—all of which goes into the decision to refresh and update the content provided.[39] The end goal is to make learning more digestible and valuable to the user.

Several companies, such as Content Technologies Inc., JustTheFacts 101, and Cram101, have demonstrated the potential of AI through smart content in the classroom. In the case of Cram101, AI is used to analyze textbook content and break it down into more digestible segments that can function as study guides. Cram101 AI pairs content-digestion with opportunities for learners to test their knowledge as they progress. This is done by integrating multiple-choice quizzes, or flashcards after a new concept or critical piece of information has been learned.[40] Highly applicable in the K-12 education space, smart content is also increasingly utilized to support lifelong learning and career upskilling.

In addition, AI may aid personalized learning through adaptive software and smart or customized content. This can help with some of the challenges faced by teachers in terms of providing customized instruction given the challenge of scaling personalized lessons to numerous students. Adaptive educational software could help identify skills gap or challenges, then deliver content and modify student material or curriculum as needed to improve learning outcomes.[41]

AI Assistance for Educators

Although the immense benefits provided by human educators cannot be overstated, the growing capabilities of AI are introducing interesting opportunities to assist teachers. AI has a wide variety of applications for aiding teachers in their day-to-day tasks and improving learning outcomes.

Some exploratory AI projects assist in automatic test generation and assessment with the goal of reducing teacher workloads. Current AI systems can combine evidence from complex and varied sources of data for pattern recognition. This could help evaluate student homework, drawing data from individual student history and peer responses. It is hoped that accumulated assessments could be more responsive and make high-stakes testing redundant.[42] Real-time assessment may also help teachers optimize collaborative learning plans and predict which students are at-risk of failing to graduate, so that proactive solutions can be developed. Other AI software offers teaching assistance for targeted, corrective feedback to aid student learning, and there is evidence that this AI-assisted instruction can lead to improved STEM learning outcomes.[43] This can help teachers analyze student data and adjust their lesson plans to best help students succeed.

Ultimately, AI is a tool that shows promise in supplementing rather than replicating the efforts of teachers. It has been noted that there are opportunities to help teachers that are increasingly challenged by longer working hours, more complex student needs, and growing administrative burdens. A recent McKinsey survey found that teachers are working an average of 50 hours a week, "a number that the Organisation for Economic Co-operation and Development Teaching and Learning International Survey suggests has increased by 3 percent over the past five years."[44] While most teachers report enjoying their work, they do not necessarily enjoy late nights of marking, lesson plan preparation, or paperwork: there are emerging opportunities for AI and other automated technologies to streamline workflows to allow teachers to concentrate on areas that technology fails to emulate, such as inspiring students, building positive class climates, resolving conflicts, creating connections, and mentoring students.[45]

While there are numerous positive opportunities for the growing use of AI in the classroom, there are also some concerns that should be considered. For example, the use of AI could lead to new challenges related to the role of privacy and data use, requiring continued analysis and investigation. It should also be noted that since AI learning algorithms are based on historical data, they tend to see the world as a repetition of the past, which could come with ethical considerations. Some researchers have noted that using AI assessment is likely to be based on criteria that could reflect cultural biases or narrow measures of success. Furthermore, AI systems may have difficulties dealing with students who are creative, innovative and "not only average representations of vast collections of historical examples."[46] For now, we are just scratching the surface on this AI capability, with more research required in the coming years to evaluate and measure outcomes, obstacles, and opportunities.

Educators Speak Out:

Challenges or Barriers to Technology Integration in the Classroom

Tech Training for Educators

When it comes to tech integration in the classroom, one of the most commonly highlighted barriers noted by educators in this study is teacher training. Specifically, **interviewees overwhelmingly agreed that educators need additional training and professional development to properly integrate new digital tools and innovations in the classroom**. Issues raised included the educators' level of comfort utilizing digital technologies and a **lack of sufficient training opportunities and resources to make this journey smoother.**

> ***"There are barriers for teachers. I think they have to do with the teachers' comfort in using new technology and the support for making it work properly."***

Reflecting on their own skills and abilities, **the majority stated a mixed level of "readiness"**

in their ability to embrace technological change. While a small minority felt that they were making excellent use of new digital tools and teaching techniques, many expressed that they are struggling. Interviewees articulated numerous areas of expertise that teaching requires (including pedagogy, classroom management, course structure planning, meeting curriculum requirements)—with these being the "core" components of the role of an educator, **several expressed difficulties balancing additional needs like integrating technologies into their roles, especially without additional training**. Coupled with the reality that technology moves very quickly, **many educators highlighted the challenge of learning how to better utilize new tools, while balancing professional development and needs in other areas.**

One example of support for educators in this realm is **Apple Teacher**. Apple Teacher is a free professional learning program designed to support educators that are using Apple products for teaching and learning. The program helps to **build skills on iPads and Macs that can then be applied to activities with students.** With the Apple Teacher program, an **educator can also earn recognition for the new skills that they have acquired**, something that can further support the education and training journey. For teachers that need to learn the fundamentals of Apple products, they can also get free support from Apple's professional learning specialists, found in the **Apple Teacher Learning Centre**.[47]

Returning to the concept of a "recognition" program for teachers who gain new skills via the Apple Teacher program, **interviewees identified micro-credentialing as a way for teachers to gain new skills and bridge gaps**. **Micro-credentials were viewed positively as short-duration training that could expand a teacher's proficiency with new technologies, but also provide the nuance of knowing when (or when not to) use new digital technologies.** Many believe that there is a proper time and place to use technology in education, and that it is not a one-size-fits-all approach.

> ***"Teachers should have more training on when it is a good time to use technology and when it's not a good time [to use technology]. It's not necessarily always being used as effectively as it should be."***

In addition to micro-credentials, several interviewees expressed **support for the idea of opportunities or partnerships with industry and external organizations—this is something that can be applied both to training as well as policy development on important considerations like procurement**. However, while many viewed this kind of partnership as positive, **concerns were highlighted regarding the increased business (company) presence in classrooms and what this might mean for students.** Balancing these objectives in a transparent and responsible manner is critical.

"I think the use of technology in the class is going to be increasing. And it's not necessarily bad. I think teachers just need more support and help with fixing things…as well as training and updates with new technology."

The sentiments expressed by interviewees are in-line with those of other research studies conducted across Canada and the United States.[48] For example, a **2018 PwC study surveyed 2,000 K–12 teachers and found that only 10% reported feeling secure in their ability to incorporate "higher-level" technology into their classrooms**. The vast majority expressed a strong need for quality training programs on emerging tech.[49] In terms of confidence in the ability to use and integrate specific technologies, educators in this study reported the following:

- 12% reported having the skills necessary to use and teach with robotics;
- 11% reported being proficient with data analytics or graphic design;
- 8% were familiar with some computer programming.[50]

In general, **erratic training and support, as well as lack of time and incentives to explore technology integration have all been cited as reasons for limited transformation of classroom teaching, despite increased investments in technology**. Interviewees provided suggestions for training that would prove effective on this journey, including the following:

- The need to emphasize continuous training or lifelong learning throughout teaching careers (rather than just in initial training);
- Teachers need to know when to (or when not to) use technology in the classroom and how to avoid using it in a shallow or basic manner;
- The need for training in how to use technology for effective communication (not just technical aspects);
- The need to help teachers understand how to integrate technology rather than simply requiring tech usage;
- The need to showcase the benefits (to teachers) of understanding emerging major changes in technology such as big data, machine learning, blockchain etc.;
- The introduction and development of micro-credentials for teachers.

"Offering training not just in the first year but also in subsequent years. I think there needs to be more training for teachers on a more regular basis with the technology that we already have."

Costs and Access

Costs and access were also highlighted as major barriers to implementing technology in educational settings. This is exacerbated by the rapid pace of technological change, since many devices have a limited functional lifespan and the costs of keeping equipment updated, secure, and in functional condition can be high. Interviewees noted that the cost challenge to be two-fold, impacting both schools and students:

- **School districts do not always have effective procurement policies in place, and therefore cannot necessarily afford to keep up with the costs** of acquiring, maintaining and operating new technology. **In some cases, teachers find themselves purchasing technologies out-of-pocket**;
- **Students and their families often struggle with the costs of ensuring they have home access to personal electronic devices** that are increasingly needed for education.

These barriers were accentuated by interviewees from smaller school districts. They emphasized the inability to fundraise for classroom equipment and the challenges that families face when sourcing equipment for their children (under BYOD programs). Overall, **technology devices in the classroom (via BYOD) were highlighted as possible contributors to broadening socioeconomic inequalities and gaps**, where some students can afford top-of-the-line smartphones, tablets, and laptops, while others are limited to far more basic school-provided devices.

The Procurement Puzzle: the need for effective procurement policies in Edtech

As identified earlier, high technology cost is one of the major challenges facing schools across Canada and around the world. While money allocated for new technology should be spent by decision-makers as strategically as possible, oftentimes schools lack the appropriate infrastructure such as industry partnerships or effective procurement policies to enable this. Strategic and results-based procurement policies and practices are key to ensuring that all spending decisions are as efficient and as effective as possible. The goal behind spending on technology should be getting the best product on the market that provides maximum benefits in areas of content availability, training for teachers, and follow-up support from vendors after sale. Since most schools currently lack advanced procurement practices, they often have limited understanding of the wide range of tools available on the market and their benefits education. This must be addressed in the interest of getting the best technology into the hands of students as effectively as possible.

Broadband Connectivity

In 2016, the CRTC ruled that broadband internet access is a basic telecommunication service that should be available to all Canadians. **Internet access is foundational for supporting digital learning, as it acts as a basic pillar of any future-oriented education system that democratizes student access to information and educational content**. Access to the internet also enables teachers to leverage cutting-edge teaching tools, eliminates geographical barriers, and facilitates interaction with teachers and colleagues.[51] Advancements in connectivity have provided opportunities for initiatives like the Inuktut Language Project, funded by the National Research Council, to encourage the preservation of regional language dialects. The project harnesses reliable connectivity to host dialect-specific search engines, translations programs, spell-check tools and other software while advocating for Indigenous rights and cultural preservation.[52]

Over the last three years, provincial governments have been working toward achieving similar results and bringing high-speed internet to all schools in Canada. For instance, in 2017, the Ontario government announced its plan to improve high-speed broadband internet in schools through investing in new fibre-optic infrastructure and network capacity across the province. The goal of this initiative it to ensure that by 2021 all students have access to high-speed internet. [53] [54]

However, **access to internet in Canada is far from universal or uniform**. In discussions with educators, it was highlighted that **numerous communities lack high quality broadband access, in some cases depriving them of opportunities to use and integrate technology in education**. **Broadband connectivity was one of the top identified barriers to increasing the presence of technology in the classroom**. The availability of fast and robust internet connections is essential for many applications, and especially those related to the ability to communicate, stream video, and utilize cloud-based software.

Many educators noted that **smaller or more isolated communities often suffer from limited bandwidth, slow satellite internet technologies, or intermittent service**. While it is well-known that there are significant connectivity challenges in northern Canada, several interviewees expressly stated that **poor connectivity was a prominent issue on Indigenous reserves and in rural regions, which impacted both students and educators, alike**.

One interviewee added that **in areas with connectivity challenges, educator comfort with common business platforms, such as Microsoft's PowerPoint, was also limited.** However, with some schools and regions facing more pressing social challenges related to access to clean drinking water and basic digital literacy skills, educator training on more advanced platforms can be a low priority.

Bringing Digital Learning to Classrooms in Canada: K-12 and Beyond

Although digital tools continue to disrupt and alter the traditional educational system, there is no uniform solution that can instantly reshape the learning process. Transformation of the education system is a long and complex process and one that should be based on a collaborative and iterative strategic approach that focuses on desired student outcomes and long-term goals.

Educators need to focus on closing the achievement gap while simultaneously making sure that all students are prepared to compete and contribute to the digital economy, with relevant competencies and skills.[55] Underscoring this need, one study indicated that **56% of parents with school-aged children representing urban, rural and suburban communities in Canada are concerned that their children may not be learning the right skills at school to be successful in the emerging economy**.[56] At the same time, **over 78% of parents believe that the best way for their children to develop skills needed for future success is to use technology at school**.[57] A vision of success for educators would incorporate learning pathways like college-ready, career-ready, and citizen-ready skills[58] together with personalized learning approaches that address a child's unique educational needs. **Increasingly, this holistic learning pathway is considered inseparable from technology**.

E-learning and Blended Learning

Over the past decade, principles of *e-learning*[59] and *blended learning*[60] have been adopted across all 13 provinces and territories in Canada. In fact, **the number of K-12 students**

engaged in distance and online learning has remained relatively steady over the past six years, while blended learning activities have shown a sharp increase. Based on enrolment data for 2017-2018, the number of students engaged in K-12 blended learning was around 12.8% of the overall K-12 student population in Canada. Although engagement ranged across provinces, **Nova Scotia showed the highest enrolment rate [in blended learning] totalling at 81.7%**.

While still in their early phases, some of the benefits of e-learning and blended learning are already clear. According to recent research, **students who choose to take online courses can feel more prepared for post-secondary learning because they are better equipped as independent learners**.[61] Students with previous e-learning experience tended to showcase higher levels of motivation in these subjects, something that was reflected in better final grades.[62] Research **has also indicated that e-learning can act as a method for decreasing dropout rates and increasing high school completion among students with disabilities and Indigenous communities**.[63] In rural Newfoundland, Indigenous students reported that through online education, they **gained confidence from completing and succeeding in the same course as other students from across the province**—through access to e-learning, they felt that more post-secondary opportunities were open to them.[64]

Case Study: E-learning in Ontario

The province of Ontario is testing a number of interesting initiatives related to the implementation of technology in the classroom. A major shift in how education is delivered resulted in the development of **e-learning credit courses being offered to students in Ontario secondary schools**. **In 2006, the provincial e-Learning Strategy was launched in eleven school boards across the province with the aim of providing unlimited opportunities to learning within a changing digital environment**. According to surveys by the People for Education, in 2019, **87% of Ontario high schools had students enrolled in e-learning**. While these courses were primarily designed for students who want to fast track through the education system or catch up on credits, **e-learning can also be used to accommodate special learning needs or provide access to courses that may otherwise be unavailable in certain communities.**

Further focusing on the integration of technology in the classroom, in March 2019, the Ontario government announced its new vision of the education system. Entitled "Education that Works for You" these efforts will involve the continued development of a new online learning system.

The Ontario government strongly believes that online courses provide students with the skills and technological fluency needed in the labour market.[65] The goals of the policy are wide-ranging, and include outcomes such as teaching students how to learn effectively in new environments and preparing students for online training in the workplace.[66] Other education districts that are including e-learning in their curricula are Michigan, Florida, Alabama, Virginia, and Arkansas.

Technology in Indigenous Classrooms

Case Study: Saskatoon and the use of Digital Technology for Indigenous Teaching

The University of Saskatchewan and the Indian Teacher Education program have recently joined forces to bring historic or traditional lessons into modern classrooms and curricula. Elders' wisdom of always leaving one egg in the nest when collecting duck eggs can be integrated into biology, and **VR and animation are being used to introduce other teachings into schools**. **This allows students to have more interactive experiences while still participating in Indigenous practices and engaging with traditions.**[67]

Technology training under this program focuses on incorporating local knowledge and traditional languages of Indigenous students, including collecting stories from elders to inform lesson plans. **One of the goals of this initiative is to provide materials on a website for teachers to download and incorporate into curricula**. While still in early phases, this integration of local and traditional lessons is expected to boost educational engagement among Indigenous students.

Case Study: Indigenous Communities and Connected North

Connected North, operated by TakingITGlobal, is a leading-edge program that provides digital collaboration opportunities for educators, industry professionals and members of government from across Canada to connect with Indigenous youth in remote communities. Originally founded by Cisco, Connected North **encourages student engagement in remote Indigenous communities by leveraging Cisco's two-way TelePresence video technology**.[68] This same technology is designed to leverage **real-world learning opportunities through virtual "field trips," allowing for in-person discussions, tours and training that would otherwise be unavailable in remote locations.**

"Thanks to Connect North we were able to connect with two representatives from Scotiabank in downtown Toronto. Our Indigenous students were just getting into financial math and had the opportunity to talk directly with people from the bank about issues like mortgages, financing and credit cards and all those types of things so they weren't just hearing it from me but also from other people who are working right there in the business."

A cofounder of TakingITGlobal explains that Connected North "**[provides] students with access to content that is engaging and innovative, with the hope of increasing feelings of empowerment in school and life.**"[69] Their approach incorporates key pillars that harmonize educational technologies, including relationship building, empowerment through role models, custom content, thinking beyond the classroom, adapting expectations and incorporating a diversity of voices.[70]

Case Study: Education, Coding and Economic Development for Indigenous Communities in Northern Canada

CODERSNORTH 2.0, a Northern Canadian project—funded in part by the Ministry of Innovation Science and Economic Development through the organization Elephant Thoughts—**combines a focus on computer programming with culturally relevant content for Indigenous students**. The program also **encourages female participation in the technology sector by providing girls-only coding camps and opportunities for female-specific digital internships**.[71] The program blends elements of Indigenous culture with beginner coding programs that utilize Blockly and Lego robotics. More advanced levels of the CODERSNORTH 2.0 program leverage Apple Swift, WordPress, Adobe Captivate and Scratch.

"We started off by introducing [our students] to Scratch coding, so they get the concept of block-based coding, then we incorporated Makey Makey kits. It's really cool to blend the two together. We even have these little Spark Sphero balls where they have to code them to get them to move."

Elephant Thoughts explains that "**educators see coding as a means to economic development and job growth in places that have limited opportunities… [These] platforms engage students and combat high absenteeism**… **We also see an opportunity for First Nations to have a strong voice through technology. We see solutions to teacher shortages, and much more**."[72] The program's value lies in leveraging regional cultural themes and computer programming while encouraging continued education in an accessible and respectful format.

Case Study: Indigenous Learning Technology and Oral Language Programs

In Canada, there have been notable uses of integrating technology with Indigenous oral language learning programs. For example, there is the Help Me Tell My Story (HMTMS)

holistic and interactive tool that measures the oral language development of a child. HMTMS was first launched in 2011 and then updated and re-designed in 2017. It is notable for being based on First Nations and Métis content and knowledge and is available to every Prekindergarten and Kindergarten child in Saskatchewan to improve early learning.[73] This involves the use of iPad apps, online portals, and a public website. The tool was adopted by 4,900 students (1,691 self-declared as First Nations or Métis) from 116 schools[74] and collects data from the students, their caregivers, teachers, and elders in the local community. The data uploaded from an iPad to a web portal for immediate access for assessment as part of a strengths-based community approach to learning.[75]

The use of an engaging and interactive approach rooted in First Nations and Métis perspectives is seen by stakeholders as an opportunity to bolster family engagement, student engagement, graduation rates, and encourage a holistic approach to education with culturally relevant teaching practices. Some of the advantages and benefits identified by this program include improved teacher assessment opportunities and parental engagement. The teachers doing the assessments were trained and comfortable using the educator portal, which provides timely feedback to teachers and caregivers. As a result, there was positive feedback from participants and signs of some early positive impacts on student achievement.[76]

Technology has also been used for early language learning in Nova Scotia with the Antle Discovers His Voice literacy assessment. As part of efforts to protect the Mi'kmaw language, Mi'kmaw Kina'matnewey partnered with Sprig Learning and the Nova Scotia Department of Education and Early Childhood Development to create this program.[77] It began in 2017 by using a holistic approach to learning and assessment to support oral language learning for students aged three to six. It combines the use of an iPad with a moose puppet named Antle to measure language usage and fluency at home, in school, and within the broader community. These culturally inclusive puppets wear different Mi'maq clothing and deal with different issues and family structures. It can also be used for other languages and by any teacher.[78]

The data is collected and shared to a cloud-based platform where teachers and students can login for personalized learning activities to promote language development in Mi'knaw and English.[79] The activities have been well-received by children, while teachers and parents benefit from having better assessment information for promoting early literacy.[80]

Snapshot: How Technology Can Help Students with Disabilities

Interviews with educators from across Canada highlighted several unique opportunities for utilizing technologies in the classroom to help students with disabilities. While far from uniform, "disability" refers to any long-term or episodic physical, mental, intellectual or sensory impairment that alters a person's movements, senses, or activities. These may be present from birth or as a result of injury or illness.

Examples of different types of disabilities include:

- Mobility
- Vision loss
- Hearing loss
- Communication
- Autism spectrum disorder
- Developmental disabilities (e.g., Down's syndrome, FASD, intellectual disabilities)
- Learning disabilities (e.g., ADD, ADHD, dyslexia, dyscalculia, dysgraphia)
- Mental health related
- Pain related
- Flexibility/dexterity

Some educators noted that technology helped them provide additional flexibility in sharing education materials and tracking assignments. For example, the use of individual learning programs can offer students the ability to work at their own pace. It allows them to reread lessons with written and visual cues to ensure the material is fully understood and digested. This is of particular benefit for those with mild learning disabilities, particularly in the areas of reading or writing.

The use of assistive technology is another clear example of how students with disabilities can benefit. **Interviewees specifically noted that broader integration of technology in the classroom removes the stigma of assistive technology for students with functional needs for education**. While 10 years ago, technology may have been an identifier of a student with a disability, today, it can unite and bring students together.

A common example is text-to-speech software, which can help students who have difficulties reading standard print.[81] Educational software offerings from the large technology companies in this space are also working to improve accessibility through the use of a variety of features such as high-contrast modes, screen magnifying/resolution options, predictive text, and guided access for those with autism or other attention or sensory challenges. [82] [83] This was experienced first-hand by one Canadian educator interviewed in this study who noted **witnessing verbal translation (via voice-to-text software) help bridge the communication divide for a deaf student who was also learning English**.

"I give [my students] what I call "read, watch or listen" each week [using various technologies]. The feedback I get is phenomenal. They're so appreciative of having other ways of accessing content for different learning styles and barriers. There is a marked component, so they have to get involved, but getting them to respond to the issues that we're looking at each week seems to work really well."

Leveraging Universal Design

Universal design (sometimes referred to as inclusive or barrier-free design) refers to design principles that aim to improve products or places so that they can be understood, accessed and used by all people regardless of age or ability.[84] Elements of universal design that aid in accessibility can help multiple groups that face challenges. For example, **digital technologies and live captioning for assisting with auditory impairments can also help other groups who face language barriers**.

"The nice thing about technology is that it has the ability to allow students from all different learning styles, all different learning abilities, and all different cultural backgrounds to actually customize their learning to a level that they like and to find content that they enjoy at the same time."

Auditory Impairments

According to the Canadian Association of the Deaf, approximately one out of 10 Canadians experience some degree of hearing loss.[85] As technology's presence within the classroom expands, its ability to assist these students greatly increases. For example, **technology can be used to assist those who experience some degree of hearing loss through the use of audio text captioning, live captions,[86] text-to-speech or speech-to-text dictations, or via the integration of electronic devices and hearing aids** (with different modes to emphasize different frequencies or uses). [87] Another example are options to switch to mono audio (instead of stereo audio), with the ability to play the same sound through both speakers or headphones. This helps users who have hearing loss or are hard of hearing in one ear better engage with an auditory experience. In an increasingly diverse and internationally connected world, the ability to support multiple auditory needs can assist students in adjusting to new learning settings.

Visual Impairments

Technology-based opportunities and applications can also be used to help those with visual impairments as classified by the World Health Organization. This can range from vision impairment (any loss or abnormality in an anatomical structure or a physiological or psychology function) that is not traditionally addressed by usual means (such as glasses) to colour blindness (that can make reading and other activities more challenging), or blindness (for complete or near complete vision loss, resulting in social disadvantages).[88] Given these challenges, a number of solutions or features have been designed to help address specific barriers. Some **common accessibility features for those who have vision**

challenges include the ability to adjust text size, screen magnification, screen readers (synthesized speech) for description, adjustments to mouse cursor size, high-contrast modes (aiding visibility), colour options (for colour blindness), and braille device support. It is also possible to have selective inputs to highlight text with 'select-to-speak' capabilities or help with device navigation and descriptions of what is being displayed on screen (even for those unable to see).[89]

Physical Impairments

Technology can aid students who face physical impairments or coordination challenges preventing their ability to fully participate in class.[90] While touch screens can require a certain level of dexterity, **UI (user-interface) / UX (user experience) design considerations are increasingly considered for improving usability. Examples include the development of touchscreens that can be controlled by an external switch or by general screen taps, head movements or face gestures**.[91] 'Sip-and-puff' or 'sip 'n' puff' is an assistive technology used to send signals to a device using air pressure by "sipping" or "puffing" on a straw, tube, or "wand." It is primarily used by people with impaired hand dexterity.

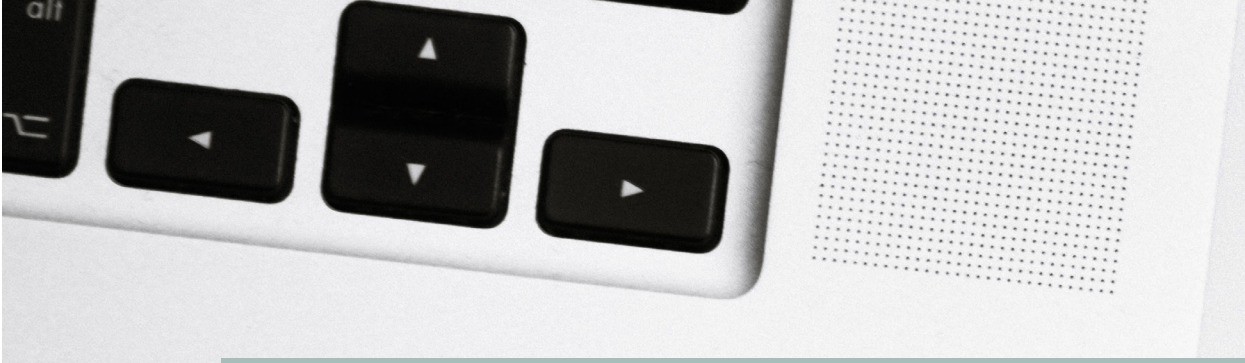
Customized touch gestures, other inputs, or adaptive controls that substitute for touch screens are also becoming more commonplace. Even at a basic level, the ability to adjust tap controls and screen sensitivity can to aid navigation and device usage. An example is replacing the need for physically clicking a mouse (which can be a dexterity challenge) with automatic clicking when the cursor stops moving.[92]

Learning Disabilities or Developmental Disabilities

Digital technologies also have numerous possible applications to assist students with learning or developmental disabilities and reduce perceived difference among peers. One report found that between **80% and 85% of special education students can meet the same achievement standards as other students**[93] **if they are supported by specially designed instruction, appropriate access, and accommodations**.[94] The appropriate and thoughtful use of education technology can be part an overall strategy to support students with disabilities and reduce achievement gaps.

Autism refers to a range of conditions resulting in challenges associated with socialization, behaviour, and speech. Technology application to these challenges is equally diverse.[95] Technology has assisted students who may need, for example, more immediate answers to questions or feedback. This is facilitated by devices that provide real-time communications (without interrupting the classroom lessons).[96] Software can also be used to help students focus on the tasks at hand, with key examples being Apple's Guided Access. **Guided Access helps those with autism or sensory challenges by restricting access or inputs to electronic devices, thereby limiting distractions**.[97] Other software

features can help condense long text passages to make them more digestible to different audiences and aid in understanding.[98] The benefits provided by computer-assisted instruction and software for students with disabilities are key to creating an educational environment where everyone can excel.



Conclusion

Efforts to better incorporate technology into K-12 classrooms have existed for decades, but new opportunities continue to emerge with the power and ubiquity of modern electronic devices. Guided by first-hand insights from education experts across Canada, the notion of technology in the classroom is perceived as largely positive. It has long been recognized that technology in the classroom offers opportunities to access learning materials, knowledge, and connections from around the world. With the continuing evolution in products and services, from simple cloud-based software to sophisticated AR/VR applications for learning, technology can bolster engagement by empowering student learning in a manner that best suits individual styles and needs.

The internet has made the world a smaller place through increased global connections and communications that allow better distribution of knowledge. Technology provides unique opportunities to help reduce educational inequalities and achievement gaps among all students, including those from different backgrounds or with different abilities. At the same time, the use of new technology encourages students to shift in how they think, collaborate, and address problems.

While effectively integrating technology into the classroom has its challenges—including its incremental costs, broadband access, cultural nuances, educator training, and the need for efficient procurement policies and practices—it is also essential if students are to acquire the skills they will need in the future. Increasingly, digital skills and competencies are required to navigate many global challenges and students need to gain these skills early in their educational journey.

Appendix A: Research Methodology

The research methodology used in the development of this report consisted of a combination of primary and secondary research.

Primary Research

The primary research for this study consisted of a series of sixteen key informant interviews (KIIs) with Canadian educators and education subject matter experts from across the country. KIIs played an important role in gathering insights on trends and needs of K-12 education. Candidates were selected based on their location (urban and rural areas, as well as Indigenous communities), role or responsibility, relationship to technology, administrative leadership and/or influence on teacher training and use of equipment.

A series of structured interview questions were designed to identify the candidates pre-existing relationship to technology, student learning, influence on curriculum and policy, current use of education-related technologies and independent views toward technology trends. Qualitative data was extracted in aggregate from these interviews to form the basis for this study.

Secondary Research

The secondary research for this study focused on an analysis of literature. A robust literature review was identified and used to highlight or clarify key themes, trends, and emerging realities.

Limitations of Research

While ICTC attempted to ensure that the research process for this study was as exhaustive as possible, there were limitations. The first is the relatively small sample pool of interviewees (sixteen). This means that while interesting, these responses must be regarded as insights and cannot be taken as objective “trends” that represent the whole country.

This report also discusses perceived barriers to education for people with disabilities, as they relate to the integration of technology in educational practices. Efforts were taken to ensure that the language used is in accordance with the UN Convention on the Rights of Persons with Disabilities, however, it is recognized that language and terminology used may become out-of-date. ICTC aimed to use the most respectful words possible while writing these materials (while acknowledging that the most appropriate terminology may change over time) and has conducted this research with the intent to respect the dignity and inherent rights of all individuals.

Appendix B: International Classroom Education Case Studies

Bangalore, India

In a government school in Bangalore, consumer technologies have been used to engage students in Grades 4 to 8 in various subjects such as Math and English. This involved the use of laptops, Google Cardboard, and Microsoft Kinect in order to introduce new activities and explore various subjects. These different VR and AR devices were incorporated into lesson plans for a variety of benefits.

The primary goal of these efforts was to make the classroom and lessons more engaging and exciting by allowing students to virtually explore, for example, ancient Egyptian tombs during history lessons.[99] The use of VR technology allows for virtual field trips or immersive videos about international locations, such as New York, Ukraine, Syria or Sudan, to give students a better understanding of the world around them. This was particularly useful, given that most of the students had never travelled beyond their local community.

This work led to increased student engagement and expanded to the use of motion-sensing math games (that encourage students to move around) and AR tools for other subjects. Some of the benefits from student interest in these devices included increased curiosity, vocabulary and student participation. These developments ultimately allowed students to feel more comfortable using digital technologies and tools, thereby better preparing them for the future. The teachers administering this technology noted that students were able to use the computers and mobile devices to express themselves with digital presentations and videos.[100]

Minnesota, United States

An example of classroom technology integration and the benefits of 'gamification' is found at the Parkview/Centre Point Elementary school in Maplewood, Minnesota. Third-grade teacher Ananth Pai is identified as a pioneer in the gamification space for using a combination of his own money and grants to acquire laptops, desktops, Nintendo DS's, digital voice recorders, and 18 educational games to provide a different learning experience for his class.[101]

These devices and educational games enable students to participate in lessons at their own speed (or level of comfort). Pai's third-grade students competed in educational games with other kids from around the world or engaged in independent learning.[102] For example, some of these imaginative settings included learning fractions and decimals by riding a virtual ghost train or virtually growing flowers or playing games that introduce civics concepts. "In a gamified classroom, the time allocated to each topic varies but the learning is constant," Pai said. "You are advancing at a different pace from another student, but

you're advancing nonetheless; that's what works."[103] Notably, while students have access to these devices and games, they still rely on a website to organize the curriculum.

There have been improvements in student reading and math scores from below average for the third grade to mid-fourth-grade levels. This positive impact was evidenced throughout the majority of the student population, with students retaining some of these advantages when returning to traditional classroom settings in later years.[104]

Odder, Denmark

The small Danish municipality of Odder devised a new public schooling strategy (Strategy for Future Public School 2012-2016) with the aim of creating a varied and challenging learning environment by using digital tools.

Local schools wanted a way to keep up with the changing developments in society and looked to introduce a greater digital presence in the classroom. As part of this strategy, 2,500 digital devices were distributed. [105] Increased motivation, engagement and netter learning outcomes were observed when these devices were incorporated into lesson plans and properly assessed, whereas classes with insufficient planning and support saw few benefits and even found negative impacts as a result of introduction of this technology.[106]

An example of how these tools were incorporated is the use of tablets to substitute for musical instruments in the classroom. This had the benefit of increasing accessibility and variety of (digital) instruments and sounds, as well as the ability to incorporate clips of melodies from online sources.[107] The benefits and goals of this device integration were to boost collaborative work, explore different learning models, and illustrate flexible learning outcomes.

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