

21st Century Digital Skills

Competencies, Innovations and Curriculum in Canada



Research by



The Information and Communications
Technology Council

Preface

The Information and Communications Technology Council (ICTC) is a not-for-profit, national centre of expertise for strengthening 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 an expansive 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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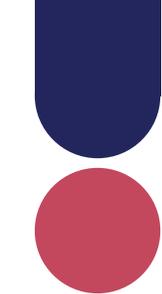


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Glossary of Terms



Augmented Reality (AR): AR overlays digital information onto the user's real-world environment in the form of words, images, video, and audio. Digital information is displayed using tablets, mobile phones, smart watches, and other wearables. Headsets that produce an AR experience, such as the Microsoft's HoloLens, are sometimes classified as Mixed Reality.

Asynchronous Learning: This style of learning means that content is designed, created, and often digitally shared with students by an instructor. Content can be accessed at different times by each individual regardless of location and organized sequentially to benefit the learner. Interaction, feedback, and formative assessment are accomplished when schedules and opportunities permit.

Data Literacy: The ability to collect, analyze, interpret, display, and challenge information from data.¹

Digital Citizenship: Understood as norms of behaviour regarding the use of digital technologies. This includes competent and positive engagement with digital technologies, active and responsible participation, and lifelong learning in both formal and informal contexts.²

Digital Literacy: The interest, attitude, and ability of individuals to appropriately use core digital technology and communication tools to access, manage, integrate, analyze and evaluate information, construct new knowledge, create, and communicate with others.³

Distance Learning/Online Learning/eLearning/Remote Learning: This report uses these terms interchangeably, despite historical nuances in definition. These terms refer to learning that occurs when classes are taught remotely (when students and educators are not in a conventional classroom setting). Remote learning may take place in times of extended interruption to in-person learning, for example, as a result of a pandemic or natural disaster. Classes can be synchronous or asynchronous and can be taught online through a Learning Management System (LMS) by using videoconferencing, smartphone, etc. In some cases, they may be delivered through emails, print materials or broadcast media.⁴

Extended Reality (XR): XR refers to any immersive environment generated by a computer and displayed on mobile or wearable technology. In that sense, XR is a substitute term for AR, MR, and VR.

Global Citizenship: Global citizenship is the umbrella term for social, political, environmental, and economic actions of globally minded individuals and communities on a worldwide scale.⁵

Human Skills (Soft/Essential Skills): Skills often attributed to intangible qualities, traits, attributes, habits, and attitudes. This includes, but is not limited to, empathy, leadership, sense of responsibility, integrity, self-esteem, self-management, motivation, flexibility, sociability, time management, and decision making. This term is used often in contrast to "technical" or "hard" skills which are deemed as highly specific in nature and often attributed to occupations or careers.⁶

1 This is a revised version of Statistics Canada's definition which reads as follows: "The ability to understand information extracted from data and summarized into simple statistics, make further calculations using those statistics, and use the statistics to inform decisions."

<https://www150.statcan.gc.ca/n1/pub/11-633-x/11-633-x2019003-eng.htm>

2 "21st Century Children as Digital Citizens," OECD, accessed Nov 2020:

<http://www.oecd.org/education/cei/21st-Century-Children-as-Digital-Citizens.pdf>

3 "Digital Literacy," Government of British Columbia, accessed Nov 2020: <https://www2.gov.bc.ca/gov/content/education-training/k-12/teach/teaching-tools/digital-literacy#:~:text=The%20Ministry%20of%20Education%20defines,create%20and%20communicate%20with%20others%E2%80%9D>

4 "Policy/Program Memorandum No. 164," Ontario Ministry of Education, August 13, 2020:

<http://www.edu.gov.on.ca/extra/eng/ppm/164.html>

5 "Global Citizenship," United Nations, accessed Nov 2020: <https://academicimpact.un.org/content/global-citizenship#:~:text=Global%20citizenship%20is%20the%20umbrella,communities%20on%20a%20worldwide%20scale.>

6 "Soft skills," UNESCO International Bureau of Education, accessed Nov 2020:

<http://www.ibe.unesco.org/en/glossary-curriculum-terminology/s/soft-skills>

Learning Management System: A learning content management system (or engine) which can be a web-based, or locally operated application for managing course communication, collaboration, administration, tracking, and reporting.⁷

Massive Open Online Courses (MOOC): Open-access online courses that allow scalable participation regardless of location, if internet connectivity is available.

Media Literacy: A set of competencies that enable individuals to interpret media, texts, institutional messages, make media of their own, and recognize and engage with the social and political influence of media on everyday life.⁸

Synchronous Learning: This style of learning means that the educational experience is taking place in real-time, via in-person, digital (video and text) and/or audio. This form of instruction allows content and instruction to be shared immediately based on a predetermined schedule. Interaction, feedback, and formative assessment often take place immediately, providing greater communication between educator and learner.

Virtual Reality (VR): VR completely immerses the user in a computer-generated 3D environment, removing as much sensory connection as possible with the real world. Visuals are displayed to users through VR headsets and head-mounted displays, which can be standalone or tethered to a computer, gaming console, or mobile phone. Spatial audio, haptics, interactive controllers, and other hardware can also be used to further intensify the experience.

⁷ "What is a Learning Management System?" University of Toronto, accessed Nov 2020:
<https://www.uts.utoronto.ca/technology/what-learning-management-system>

⁸ Hoechsmann M, Poyntz S., "Media Literacies: A Critical Introduction," John Wiley & Sons, Jan. 30th, 2020. Pg 1



Executive Summary

The rapid advance of digital technologies has significantly impacted education in recent years. It is evident that the increasing digitization of the economy and society will require students to become comfortable with technology to prepare for the future. In turn, this also requires teachers to be supported to develop the skills and knowledge required to fully utilize the capabilities of technology, whether in the classroom or in a hybridized model that utilizes distributed online learning.

Given this need to take advantage of the opportunities provided by new digital technologies, this paper focuses on the importance of training and support for teachers to ensure that they have the skills and competencies required to integrate technology into an educational setting successfully. While K-12 education has been working in this area for decades, it has adopted the responsibility of ensuring educators are able to teach effectively in both hybrid, and purely digital environments. As technology continues to change the way students learn, it breaks down the physical boundaries of classroom learning, encouraging collaboration, improved interactivity, and allows for greater flexibility for learning needs. ICTC's primary research identifies the top technical skills required by educators (such as digital literacy, information/media literacy, and LMS fluency and awareness) and the top "human" or soft/transferrable skills (such as digital curiosity, interpersonal communication, and confidence). Similarly, interviewees identified the top technical and academic skills and competencies required by K-12 students for future success (such as digital citizenship, digital fluency, coding, etc.) as well as the top human or transferrable skills needed by students (such as critical thinking, communication, and adaptability, etc.).

The report includes examples of how innovative digital technologies such as 3D printing, AI, VR/AR, Apps, Gamification, and LMS tools are being incorporated into Canadian classrooms to develop future-ready skills and competencies, and which skills and competencies are best developed through their adoption in K-12 schools.

Introduction

The global advance of the COVID-19 pandemic has created uncertainty in education: mass school closures in March 2020, re-openings in September 2020, and various measures to mitigate health risks, including masks for older children and groups, face shields, sanitizer, temperature checks, physical distancing, hybrid or distance education, and altered school-bus services.⁹ As of April 2021, the trend leans toward in-class schooling or blended learning models where the risk of school closures remains high. However, this situation remains fluid, with schools transitioning back to online learning in various provinces as COVID-19 cases fluctuate. As students continue to learn online given the widespread usage of digital technologies, online education is likely to remain a prominent theme. As a result, the need for a contemporary understanding of digital skills and competencies may never be higher.

This paper begins with the evolution of education, which provides a context for how digital technologies have been adopted in the classroom in recent years (and continue to change as new capabilities are developed). Next, it considers the evolution of educator and student technical competencies. These sections rely on insights from a series of key informant interviews with Canadian education experts to better understand the competencies required for future success. This research also investigates future-oriented digital skills and competency frameworks (drawing from both Canadian and international examples of educational models). Recent innovative applications of tech implementation in classrooms are explored as is the importance of procurement, adoption and technology-related policies in Canada. Here we build on previous ICTC discussions with educators to look at these successes and related challenges in these areas. The paper concludes with technology as a pillar of education policy and considers how an expanded role of digital technologies can positively or negatively impact issues of diversity and inclusion.

⁹ Bogart, N., "Mask mandates, class caps: Back to school rules by province," CTV News, July 29, 2020: <https://www.ctvnews.ca/health/coronavirus/mask-mandates-class-caps-back-to-school-rules-by-province-1.5042739>





Evolution of Education

Digital technology has been used in classrooms throughout the latter half of the 20th century (particularly for the delivery of educational content to users), but its usage accelerated with the mainstream adoption of personal computing and, later, ubiquitous internet connectivity and the shift to mobile devices. This has significantly altered the role of technology as it shifted from simple content distribution to opening new opportunities for teachers and students to create, communicate, and collaborate through technology. The mid-1990s marked a period of rapid development with the first online learning management systems (LMS) that provided digital teaching environments where content could be organized along with student activities, assignments, and discussion forums.¹⁰ While LMS technologies continue to play an important role in both traditional and online learning environments, as this report later highlights, it is important to note the emergence of Massive Open Online Courses (MOOC),¹¹ which allow widespread participation in the form of presentations, webinars, and other content and platforms. While participation in these online courses often lacked formal assessment in the past, increasingly enrollment and progress is now validated.¹²

In addition to the delivery of content, technology has also been adopted into classrooms through the widespread use of personal digital devices (smartphones, tablets, or laptops) or dedicated devices such as programming and robotics kits. Many new technology integrations in the classroom have been largely associated with efforts that encourage STEAM (Science, Technology, Engineering, Arts and Math) participation for students.

¹⁰ "6.2 A short history of educational technology," BC Open Textbooks, accessed June, 2020: <https://opentextbc.ca/teachinginadigitalage/chapter/section-8-1-a-short-history-of-educational-technology/>

¹¹ "A Brief History of MOOCs," McGill University, accessed: Oct 2020: <https://www.mcgill.ca/maut/current-issues/moocs/history>

¹² <https://www.coursera.org/>; <https://www.edx.org/>

Technology has facilitated more holistic education in the following ways:

Better Access to Up-to-Date Resources

- The large volume of information that can be accessed through digital technologies offers a wide array of opportunities. However, because the information that students encounter is not always accurate or trustworthy, students are required to have foundational information and digital literacy skills such as critical thinking, media literacy, and the ability to verify the trustworthiness of online sources. Similarly, this requires students to learn how to properly cite their resources and avoid plagiarism.
- Digital technologies provide new learning opportunities through online groups, virtual communities, and access to experts. This can take place through peer-to-peer learning at either the student or educator level.
- Technology can also help accommodate students with learning disabilities or physical disabilities. Additional information on these challenges and opportunities can be found in ICTC's previous education technology paper "*Class, take out your tablets: The impact of technology on learning and teaching in Canada.*"¹³
- Access to expansive, digitized Canadian educational and cultural content, such as TVO and TVO's online heritage tool.¹⁴

Expand Classroom Boundaries

- Access to subject matter experts can provide greater virtual reach, such as using Virtual Reality (VR) and Augmented Reality (AR) for experiencing distant lands or inaccessible regions like space or deep ocean topography. Likewise, distance learning networks such as 'Connected North' aim to bring valuable academic and educational resources from abroad to smaller, more rural communities.

¹³ Ivus, M., Quan, T., Snider, N, "Class, take out your tablets: The impact of technology on learning and teaching in Canada" (January 2020). Information and Communications Technology Council: https://www.ictc-ctic.ca/wp-content/uploads/2020/04/ictc_impact-of-tech-on-learning-teaching-canada_final_en.pdf

¹⁴ "TVO's Public Archive," accessed Nov 30th, 2020: <https://www.tvo.org/archive>

Engagement and Interactivity

- Presenting math problems electronically rather than physically (i.e., paper) can improve engagement and transformative practice.¹⁵ Using technologies like Augmented Reality (AR) to animate math challenges can be even more engaging. For example, AR simulations of a fictional alien crash site on school grounds have been used in classrooms to teach mathematical concepts such as proportional reasoning.¹⁶ A study of AR applications in mathematics can improve learning outcomes and motivation when accompanied by effective teaching strategies.¹⁷ For some students, interactivity provides an improved learning experience compared to traditional lessons. This paper provides a more detailed analysis of whether technology is substitutive or transformative with the SAMR and PICRAT models on page 41.

Self-Paced Learning

- It is far easier for learning to take place independently and at the home, catering to the unique needs of each individual learner. This is underscored in ICTC's discussions with Canadian educators who conceive of their role as transitioning to become a *guide* to student learning, with the student taking on an increasingly independent role.
- New forms of tech-enabled self assessment can also aid students in measuring their progress.¹⁸

Innovative Teaching Techniques

- Traditionally, education has been characterized as "teacher-centric," with the teacher owning the knowledge and transmitting it to the students through lecture and instruction (sometimes referred to as "sage on the stage").¹⁹

¹⁵ *Reimagining the Role of Technology in Education: 2017 National Education Technology Plan Update.* U.S. Department of Education, January 2017: <https://tech.ed.gov/files/2017/01/NETP17.pdf>

¹⁶ Mitchell, R. and Debay, D., "Get Real: Augmented Reality for the Classroom", *International Society for Technology in Education*, September 2012: <https://files.eric.ed.gov/fulltext/EJ991229.pdf>

¹⁷ Chao, Wen-Hung & Chang, Rong-Chi. (2018), "Using Augmented Reality to Enhance and Engage Students in Learning Mathematics." *Advances in Social Sciences Research Journal*. 5. 10.14738/assrj.512.5900.

¹⁸ Himmelsbach, V., "How Does Technology Impact Student Learning", *Top Hat*, March 15, 2019: <https://tophat.com/blog/how-does-technology-impact-student-learning/>

¹⁹ Scales, P., "'Sage on the stage' or 'Guide on the side'", *jobs.ac.uk*, June 6, 2019: <https://college.jobs.ac.uk/article/sage-on-the-stage-or-guide-on-the-side/>

- Digital technologies are being utilized as part of a larger movement toward active learning (instruction that engages students in ways other than passively watching, listening, and taking notes)²⁰ and increasingly becoming more “student-centric.” According to ICTC’s discussions with educators,²¹ teachers should help guide and facilitate active student involvement in their learning.²² This may include collaborative group work, flipped classrooms (where students are introduced to new content at home and then practice working through it at school) and hybrid classrooms.²³ Hybrid classrooms can refer to mixed models where a significant amount of teacher-led learning occurs outside the classroom along with supplemental face-to-face instruction.²⁴ In practice, this could entail delivering content online and then focusing on skills when students are in class (as it can be difficult to focus on individuals during a synchronous online lesson with numerous students).²⁵

Collaboration and Communication

- The use of shared digital archives such as wikis or Google documents for shared work efforts assists in group collaboration.
- Technology can help organize and facilitate group projects at a distance.²⁶
- Communication technologies can help address interpersonal challenges resulting from isolation or separation. A fluency in communicative technologies is an increasingly valuable skill as work-related processes become increasingly more digital (i.e. customer management, video-conferencing etc.) This is especially relevant with regards to remote-work.

²⁰ “Active Learning Activities”, Centre for Teaching Excellence -University of Waterloo, accessed Oct 27, 2020: <https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/developing-assignments/assignment-design/active-learning-activities>

²¹ 21st Century Digital Skills: Key Informant Interviews [Web Interview]. (n.d.).

Themes related to student-led learning and the deconstruction of traditional classroom learning practices were cited several times throughout our interviews.

²² Fischer, E., Hänze M., “Back from “guide on the side” to “sage on the stage”? Effects of teacher-guided and student-activating teaching methods on student learning in higher education”, *International Journal of Educational Research*, Volume 95, 2019: <https://www.sciencedirect.com/science/article/pii/S0883035518316823>

²³ “The Definition of the Flipped Classroom”, TeachThought, January 6, 2020: <https://www.teachthought.com/learning/the-definition-of-the-flipped-classroom/>

²⁴ Desetti, B., “Learning Next Fall: The Hybrid K-12 Classroom,” *Desire2Learn*, May 13, 2020: <https://www.d2l.com/blog/learning-next-fall-the-hybrid-k-12-classroom/>

²⁵ Barnwell, P., “How to Plan for Hybrid Teaching and Learning,” *Common Sense Education*, August 7, 2020: <https://www.common sense.org/education/articles/how-to-plan-for-hybrid-teaching-and-learning>

²⁶ “How Has Technology Changed Education,” *Purdue Online*, Accessed June 2020: <https://online.purdue.edu/blog/education/how-has-technology-changed-education>

Technology has been identified as a significant factor in increasing student productivity by providing motivation, rewards, and increased opportunity for creativity and engagement.²⁷ Notably, there have been substantial efforts to utilize the benefits and engagement elements of “gamification” in education such as providing “points” for achieving educational outcomes.²⁸ Some best practices for gamification to motivate student learning include concepts like “just-in-time” learning opportunities, which allow students to make connections and interdisciplinary relationships or encourage collaboration among classmates.²⁹ Gamification was identified in previous ICTC research³⁰ as highly effective and should be pursued in future research.

Education systems are increasingly looking to adopt hybridized models that take advantage of the benefits provided by both technology and in-person learning. This pertains to at-home learning, classroom management or for frequently used hardware and software. ICTC’s research indicates that the integration of technology in the K-12 education space is challenging because of the need for additional tech training for teachers.³¹ It must be introduced in a responsible way that takes the local and individual needs of students and teachers into account while supplementing pre-existing pedagogy.

Gaps in Knowledge, Support, and Training

By March 2020, citing health and safety concerns related to the pandemic, 107 countries had implemented national school closures impacting 862 million children and young people.³² Given the uncertainties of the disease and its impact on students, schools largely adopted online learning. By September of 2020, provinces across Canada had released plans to provide in-person learning options (differing by province and grades).³³ As provinces and school districts pivoted to delivering curricula online via various technologies, limitations in platform capabilities and an educator/student lack of familiarity with some digital systems created barriers to success.

27 “Reimagining the Role of Technology in Education: 2017 National Education Technology Plan Update,” Office of Educational Technology – US Department of Education, January 2017: <https://tech.ed.gov/files/2017/01/NETP17.pdf>

28 “12 Examples of Gamification In The Classroom,” TeachThought, September 24, 2019:

<https://www.teachthought.com/the-future-of-learning/12-examples-of-gamification-in-the-classroom/>

29 Hill, D., Stein Brunvand, “2.7 Gamification – Taking Your Teaching to the Next Level: A Guide for Gamifying your Classroom,” accessed June 2020: <https://edtechbooks.org/k12handbook/gamification>

30 Ivus, M., Quan, T., Snider, N, “Class, take out your tablets: The impact of technology on learning and teaching in Canada” (January 2020). Information and Communications Technology Council:

https://www.ictc-ctic.ca/wp-content/uploads/2020/04/ictc_impact-of-tech-on-learning-teaching-canada_final_en.pdf

31 Ivus, M., Quan, T., Snider, N, “Class, take out your tablets: The impact of technology on learning and teaching in Canada” (January 2020). Information and Communications Technology Council:

https://www.ictc-ctic.ca/wp-content/uploads/2020/04/ictc_impact-of-tech-on-learning-teaching-canada_final_en.pdf

32 Viner, R., et al, “School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review,” *The Lancet*, Volume 4, Issue 5, p397-404:

[https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642\(20\)30095-X/fulltext](https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(20)30095-X/fulltext)

33 Bogart, N., “Mask Mandates, class caps: Back to school rules by province,” CTV News, July 29, 2020:

<https://www.ctvnews.ca/health/coronavirus/mask-mandates-class-caps-back-to-school-rules-by-province-1.5042739>



*Nobody should be expecting teachers to perfectly replicate what goes on in the classroom, online. Realistically, this is not replicating. It's not online instruction even...I've heard it referred to as emergency remote teaching. And given a crisis, that's all that can be expected.*³⁴ 

– Patrick Maze, President of the Saskatchewan Teacher's Federation

Prior to COVID-19, schools often required faculty who were already comfortable with digital systems to manage their online online initiatives and activities—both in class and for the school at large.³⁵ ICTC's 2020 study, *Class, Take Out Your Tablets: The Impact of Technology on Learning and Teaching in Canada*, cites two primary challenges to effective tech adoption by educators:

- 1** Lack of available support for IT services at the school level, and
- 2** Lack of training and long-term support provided by vendors for new technologies and equipment.³⁶

Undoubtedly, educators who lack support or familiarity with digital systems are bound to see limited success in teaching in the future.³⁷

³⁴ Gillis, T., "Don't beat yourself up over what you can or can't do: Teachers, families face challenges educating at home," CBC News, April 28, 2020: <https://www.cbc.ca/news/canada/saskatchewan/teachers-families-facing-learning-challenges-1.5547783>

³⁵ Howell S. and O'Donnell B., "Digital Trends and Initiatives in Education: The Changing Landscape for Canadian Content," Association of Canadian Publishers, March 2017: <https://publishers.ca/wp-content/uploads/2019/03/DigitalTrendsandInitiativesinEducation.pdf> Pg. 4.

³⁶ Ivus, M., Quan, T., Snider, N., "Class, take out your tablets: The impact of technology on learning and teaching in Canada" (January 2020). Information and Communications Technology Council: https://www.ictc-ctic.ca/wp-content/uploads/2020/04/ictc_impact-of-tech-on-learning-teaching-canada_final_en.pdf

³⁷ Howell S. and O'Donnell B., "Digital Trends and Initiatives in Education: The Changing Landscape for Canadian Content," Pg. 4.

Educator and Teaching Transitions

While the use of technology at the school level expands, a systemic shift is also taking place. This includes the relationship between students, educators, and technology. A 2019 report³⁸ outlines this shift:

Figure 1: Pedagogical changes from traditional teaching practices to digitally assisted learning



³⁸ Howell, S. and O'Donnell B., “Digital Trends and Initiatives: The Changing Landscape for Canadian Content,” Association of Canadian Publishers, March 2017: <https://publishers.ca/wp-content/uploads/2019/03/DigitalTrendsandInitiativesinEducation.pdf>

FROM

TOWARD

Teacher who integrates little or no technology...



Learning in a physical space...



The classroom is only one place for learning to take place. **Flexible learning models and environments are enabled by technology and extend outside the classroom** (blended and online learning, Learning Commons, field trips, etc.).

Students learn through multiple approaches such as intentional instruction, cooperative activities, and problem-solving/inquiry tasks. They use technology (computers, mobile devices, digital cameras, etc.) as well as print and digital resources (books, eBooks, videos, audio, simulations, etc.) as tools to support them. An increasing number of students use their own mobile devices to learn anytime, anywhere.

Teacher who uses limited approaches and technology to access professional learning...



Teachers are a diverse group of life-long learners. They engage in continuous self-directed and collaborative or community-based professional learning through digital content and multiple technology-enabled approaches.

Teachers are exploring emerging pedagogies and learning how to effectively use technology by engaging in action research, professional learning communities, reflective practice, and online learning. They have access to eBooks, websites, webinars, webcasts, articles, blogs, videos, wikis, discussion boards, etc. to support their individual professional learning goals.

Source: Howell, Susan and Brian O'Donnell, "Digital Trends and Initiatives in Education: The Changing Landscape for Canadian Content."

The figure above highlights the disruptive implications of digital learning and teaching, related competencies, and methodologies, which are further noted by other Canadian research:

 *Distributive or distance learning models, enabled through advances in technology, intelligent software, and multi-media provide increased access, flexibility, and choice as well as challenges for both learners and teachers. Virtual social connections and the role of educators and teacher training are identified as essential factors to optimizing e-learning experiences and outcomes.*³⁹ 

Personal connections between educators and their students as well as students and their peers remain important—even as we continue turning to e-learning experiences. National education research by the Social Sciences and Humanities Research Council of Canada recognizes that peer connections influence motivation, endurance, deep learning, and critical self-reflection.⁴⁰ This research also notes that virtual communities will be an important factor in learning, as they encourage online communication, collaboration, and interpersonal relationship building. ICTC’s interviews emphasized the importance of ensuring that teaching goes beyond the learning of facts or performing well on examinations and tests:

 *Our problems in teaching become more advanced with technology. We need to change how we look at student learning. Not just learning to take tests but learning for life.* 

– Educator, Newfoundland and Labrador

There is some concern about Canada’s ability to take full advantage of these new technologies. While Canada’s urban centres are well-positioned in information and communication technologies (ICT) and typically possess stronger telecommunications infrastructure, e-learning in rural Canada has been described as “loose, uncoordinated, and fragmented” with a strong need for more cross-jurisdictional and institutional e-learning initiatives.^{41,42,43}

³⁹ “Leveraging Knowledge for 21st Century Teaching and Learning: Insights and opportunities for knowledge mobilization and future research,” Social Sciences and Humanities Research Council of Canada, June 2016: https://www.sshrc-crsh.gc.ca/society-societe/community-communite/ifca-iac/01-learning_report-apprentissage_rapport-eng.aspx

⁴⁰ Ibid.

⁴¹ Durier-Copp, M. et al., “Strengthening deeper learning through virtual teams in e-Learning: a synthesis of determinants and best practices,” SSHRC Knowledge Synthesis Grant final report, November 2015

⁴² “Ontario Improving Broadband and Cell Service for Rural communities.” Government of Ontario, June 3, 2020: <https://news.ontario.ca/en/release/57104/ontario-improving-broadband-and-cell-service-for-rural-communities>

⁴³ “High-Speed Access for All: Canada’s Connectivity Strategy.” Innovation, Science and Economic Development Canada, 2019: https://www.ic.gc.ca/eic/site/139.nsf/eng/h_00002.html

Changing Role of The Educator

A central theme that emerged from ICTC's interviews is the evolving relationship between educators and new technology. An ongoing pedagogical transformation in teaching principles reflects the ongoing shift in the role and importance of technology in the classroom. One respondent with 15+ years of teaching experience noted that students are often more familiar with the technologies being leveraged than their instructors. This transition has amplified the value and importance of the educator as the facilitator of learning, and poses a challenge to finding unique ways to connect technology to the curriculum:

Reaching out to other humans through the connected power of technology becomes hugely disruptive to the educational process. You can have an environment where you come to class not knowing the answer to something, and you can work with other kids to find the answer. It's a fundamental shift for the teacher... We can actually "walk in the uncertainty" and bring the true uncertainty of the real world into the classroom. ■■

– Post-Secondary Digital Learning Strategist, Ontario

Another respondent shares a similar perspective, commenting that educators are now focusing on human skills, such as critical thinking, creativity, and adaptability, as opposed to more traditional subjects such as reading, writing, and arithmetic.

Continued integration of new technology into the classroom also presents challenges such as lack of training and support, as well as a growing lack of confidence. Interview respondents frequently cited the relationship between lack of adequate training and its impact on confidence levels for both new and experienced educators. This lack of confidence also impacts the use and adoption of newer and more innovative technologies. One respondent stated that most educators use only the first few technologies they have learned after graduation.⁴⁴

⁴⁴ Ivus, M., Quan, T., Snider, N, "Class, take out your tablets: The impact of technology on learning and teaching in Canada" (January 2020). Information and Communications Technology Council: https://www.ictc-ctic.ca/wp-content/uploads/2020/04/ictc_impact-of-tech-on-learning-teaching-canada_final_en.pdf

Although there is a focus on educational technologies and digital skills, the shift of the Canadian educator to that of a “facilitator of learning” was a central theme among respondents. An important and non-technical aspect of this facilitator role was the value and importance of relationship building, interconnectedness, and community. Several respondents indicated that the relationships they fostered with their students provided value to the overall learning experience, while encouraging better completion rates for assignments and overall attendance.

Educator Competencies

This study also explores which digital skills and core competencies educators need to effectively help their students succeed. Interview responses varied greatly between technical and human skills (i.e., soft skills). While there are similarities or overlap in where skills and competencies reflect abilities of an individual (acquired through learning and experience), skills are more defined as specific learned activities.⁴⁵ In these discussions, most interviewees used the terms largely interchangeably. ‘Hard skills’ or ‘technical skills’ reflect abilities that are easier to quantify (whether language proficiency or computer programming languages) while ‘soft skills’ are subjective skills that are more difficult to quantify.⁴⁶ ‘Soft skills’ are sometimes referred to as ‘human skills’ or ‘transferrable skills.’⁴⁷ Regarding terminology, some prefer the use of human skills, as it reflects the growing importance of human-to-human connection while emphasizing the fact these skills are limited to human labour and are not vulnerable to AI, automation, or technological obsolescence.⁴⁸

Technical skills

(ranked by the number of times cited):

- 1 Digital literacy
- 2 Information/media literacy
- 3 Learning Management Systems fluency and awareness
- 4 Digital engagement⁴⁹
- 5 Data and analytics competencies

Human skills

(ranked by the number of times cited):

- 1 Digital curiosity
- 2 Interpersonal communication
- 3 Confidence
- 4 Flexibility/adaptability
- 5 Digital engagement

⁴⁵ Beckett, S., “What’s The Difference Between Skills and Competencies?”, HRSG, March 14 2018: <https://resources.hrsg.ca/blog/what-s-the-difference-between-skills-and-competencies>

⁴⁶ Doyle, A., “Hard Skills vs. Soft Skills: What’s the Difference?” *the balance careers*, Jan 20, 2020: <https://www.thebalancecareers.com/hard-skills-vs-soft-skills-2063780>

⁴⁷ “Human Skills: Definitions and Examples”, Indeed.com, Nov 27, 2020: <https://www.indeed.com/career-advice/career-development/human-skills>

⁴⁸ “Address Your Industry’s Skills Gap in So-Called “Soft” Human Skills”, WBT Systems, accessed Jan 2021: <https://www.wbtssystem.com/learning-hub/blogs/skills-gap-soft-human-skills>

⁴⁹ Note that “Digital Engagement” appears in both the technical and human skills categories, as this is a multidisciplinary skill. Although the concept of ‘engagement’ traditionally lies with issues of empathy and interpersonal communication (i.e. human skills,) this was a term often cited when speaking about retention rates, and keeping students engaged on digital platforms (LMS Systems) or via digital tools such as Facebook, Twitter, Tik Tok, Snapchat etc. (i.e. Technical Skills.)

Respondents highlighted the need for a revised educational approach when incorporating or focusing on technology in the classroom. The concept of “inquiry-based pedagogical methods” was cited, denoting a position that places a student’s independent exploration of material at the centre of their learning journey.

The term “Digital Curiosity,” used frequently by respondents, describes an educator’s ability to learn, explore, navigate, and even fail when leveraging new software/hardware. This is different than “digital literacy,” which has been described as “the interest, attitude, and ability of individuals to appropriately use digital technology and communication tools to access, manage, integrate, analyze, and evaluate information, construct new knowledge, create, and communicate with others.”⁵⁰ In other words, “digital curiosity” is an interest in learning new technology whereas “digital literacy” is a competency in using core technologies. As digital literacy refers to the ability to utilize new technologies, it is considered a technical skill (entailing specific functional usage). Conversely, ‘digital curiosity’ reflects a specific facet of human curiosity related to learning and exploration (involving technology), and is therefore categorized as a human or transferrable skill.

The category “interpersonal communication” includes elements of non-verbal and relational communication such as understanding of how messages are provided and understood as well as the medium in which they are used.⁵¹

The adoption of online learning demands new competencies for educators. Some school districts are providing educators with guidance for best practices as they manage this transition, as some of the following guidelines illustrate:

- Teachers should use their professional judgment to determine how to best support learners through remote learning
- Provide continual feedback on literacy and numeracy related learning standards
- Emphasize learner self-assessment but also provide virtual and telephone conferences for descriptive feedback and discussion of next steps
- Identify essential learning priorities and base assessments appropriately
- Find creative ways for learners to share what they are doing at home and generate ideas to demonstrate learning
- Consider more formalized evaluation of prioritized learning standards for Grade 10-12 students
- Consider unique needs or circumstances of individual students⁵²

⁵⁰ “Digital Literacy”, Government of British Columbia, accessed Oct 2020:

<https://www2.gov.bc.ca/gov/content/education-training/k-12/teach/teaching-tools/digital-literacy>

⁵¹ Berger, C. (2005). *Interpersonal Communication: Theoretical Perspectives, Future Prospects*. *Journal of Communication - J COMMUN*. 55. 415-447. 10.1093/joc/55.3.415.

⁵² “Continuity of Learning: Planning Guide for Teachers.” Ministry of Education, March 2020:

<https://www.sd5.bc.ca/Documents/Continuity%20of%20Learning-planning-guide-for-teachers.pdf>

Barriers to Widespread Technology Adoption

Educators who successfully adopt technology are often seen as “change agents,” acting as facilitators who help integrate technology. Change agents can confidently troubleshoot problems in technology deployment, where these same challenges often discourage others from introducing new technology in their classrooms. A fear of failure in front of students, issues of student data privacy, and perceptions of competency are deterrents to technology adoption. A discussion of these issues gave rise to a consistent narrative around the need for professional development. Although some respondents noted that professional development workshops are available, barriers to participation included funding (for substitute teachers), time constraints due to heavy workloads, and lack of consistent training opportunities.

School budgets for the purchasing new equipment can also be problematic. Issues of retiring outdated or aging technology, long-term planning for software licensing, and the development of stronger digital infrastructure are negatively impacted by annual (rather than multi-year) funding cycles. One district ICT coordinator highlighted budget issues arising from the differences in high-income and low-income school fundraising initiatives.⁵³ Money raised in high-income versus low-income schools differ, which impacts equipment purchases and extracurricular activities. These challenges can also apply to school infrastructure:

 *Classrooms need better network infrastructure. If you have more wireless devices connecting, they require internet and network access. You need improved network infrastructure such as WiFi access points and wired networking to be able to handle the increased bandwidth being accessed.* 

– Educator, British Columbia

⁵³ “Technology in schools. A tool and Strategy.” People for Education, May, 2020: <https://peopleforeducation.ca/wp-content/uploads/2020/05/Technology-In-Schools-Final-May-5.pdf>

This can also be a challenge for families, given the high financial burden of ensuring up-to-date personal computing equipment:

We surveyed our parents and 70% responded that they hadn't bought a personal computer for their home in the last five years. Most responded that they don't even own one. They're simply using their phones, which isn't a great tool for learning... So one of our biggest limitations is getting students on certain technology in the hopes this issue can be overcome. ▀ ▀

– Technology Administrator, Alberta

Technology purchases can financially strain large families when each child needs their own computer for schoolwork.





K-12 Education Competencies in Canada

Technological advances have led to significant disruptions in teaching and learning. Novel use or combinations of existing products and services, or game-changing technologies will continue to transform society and education over the next 20 years. These innovations, in addition to further disruptions linked to increased global mobility, are changing the way we learn and teach and how we think of education itself and its organization.⁵⁴

Currently, there is no unanimous agreement on competencies and best practices for integrating educational technology into classrooms; however, this paper highlights examples of what can be factored into these discussions, as policymakers and educators⁵⁵ adapt to technology advances.

Listed below is a categorization of four broad types of teaching competencies that lead to successful outcomes in the classroom.⁵⁶ Each of these competencies have significant technology implications:

⁵⁴ "Leveraging Knowledge for 21st Century Teaching and Learning: Insights and opportunities for knowledge mobilization and future research," Social Sciences and Humanities Research Council of Canada, Accessed November 2020: https://www.sshrc-crsh.gc.ca/society-societe/community-communite/ifca-iac/01-learning_report-apprentissage_rapport-eng.aspx

⁵⁵ "ISTE Standards for Students," International Society for Technology in Education (ISTE), Accessed November 2020: <https://www.iste.org/standards/for-students>

⁵⁶ "Teacher Competencies," The Wing Institute, Accessed June 2020: <https://www.winginstitute.org/quality-teachers-competencies>

Instructional Delivery

The instructional strategies and practices of individual teachers have a significant impact on student learning. Heightened learning occurs in a dynamic setting where teachers offer active instruction (rather than passive learning). This will be tied closely to LMS systems as teachers and students get used to increasingly student-led learning.

Classroom Management

Research indicates that classroom management is one of the most significant and persistent areas of concern for teachers, administrators, and the public. This is likely to lead to new challenges for the education system, as educators will have to consider establishing well-designed expectations and policies when integrating learning technologies. This includes distractions, off-task behaviour, and cyberbullying.

Formative Assessment

Assessment and progress monitoring are frequently identified as top factors in student success. According to the Ontario Ministry of Education, this can be interpreted as “assessment for learning” and “assessment as learning.”⁵⁷ Feedback is an essential tool for improving performance across a range of disciplines. Digital technologies offer opportunities for identifying areas of intervention to assist students as they take an increasingly self-directed role. Integration in larger LMS systems could also provide teachers better visibility of student progress. An interesting opportunity is presented by adaptive learning software that dovetails with other trends for personalized learning outcomes.⁵⁸

Personal Competencies (Soft Skills)

While there are no universally accepted personality characteristics that determine an educator’s efficacy, there are soft skills and attributes that are commonly identified as beneficial for student success:

- ▮ setting high but achievable expectations
- ▮ encouraging a love for learning
- ▮ listening skills
- ▮ flexibility
- ▮ empathy
- ▮ cultural sensitivity
- ▮ encouraging higher-order thinking alongside foundational skills
- ▮ positive regard for students⁵⁹

⁵⁷ Ontario – First Edition, Covering Grades 1 to 12, “Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools,” Ontario Ministry of Education, 2010: <http://www.edu.gov.on.ca/eng/policyfunding/growsuccess.pdf>

⁵⁸ Schroeder, R., “Adaptive Learning to Personalized Learning,” *Inside Higher Ed*, Sept 4, 2019: <https://www.insidehighered.com/digital-learning/blogs/online-trending-now/adaptive-learning-personalized-learning>

⁵⁹ “Teacher Competencies,” *The Wing Institute*

Given the increasingly distanced interactions of online communications, it will be increasingly important that these soft or transferrable skills and competencies facilitate interpersonal relationships. Furthermore, the advances of automation and other labour-saving technologies highlights the importance of empathizing soft skills and emotional intelligence, which cannot be replicated. The most frequently cited required skills for educators in ICTC's interviews were digital curiosity, interpersonal communications, and confidence. For students, frequently cited crucial skills included critical thinking, communication, and adaptability.

In many ways, the push for "21st century learning and skills development" is closely tied to the increased role of technology in the classroom (and society more broadly). Research on this topic identifies several complementary areas of interest and design considerations for future-oriented K-12 teaching competencies. These include themes such as linking teaching strategies to specific curriculum content, active learning collaboration, coaching and support through experts sharing evidence-based practices, feedback and reflection, and sustained duration (with appropriate supports in terms of time for teachers to learn, practice, implement, and reflect).⁶⁰

Many of these competencies can be acquired through professional development, which is part of a larger discussion on content delivery and teaching strategies, issues of collaboration, coaching, feedback, and sustained duration.

Respondents additionally highlighted these barriers to professional development: inadequate resources, failure to align policies or the specific needs of educators and learners, and dysfunctional school cultures. These may be addressed by a mixture of proposed recommendations such as restructuring school schedules to accommodate increased professional learning and collaboration, identifying expert teachers as mentors and coaches, assessments to align learning needs and wants, and providing flexible funding and opportunities for sustained engagement.⁶¹

The framework provided by the Council of Ministers of Education, Canada (CMEC), an intergovernmental body founded by ministers of education to provide leadership at the pan-Canadian and international level, factors into how these proposed recommendations can be integrated into the larger education system.⁶² Although not explicitly stated, many of these solutions are highly applicable when considering the impact of technology. Crucial competencies identified at a national level include critical thinking and problem-solving; innovation, creativity and entrepreneurship; learning to learn; collaboration; communication; and global citizenship and sustainability.⁶³

⁶⁰ "Rapid Synthesis: Supporting Professional Learning Approaches to Foster Global Competencies in K-12 Education," McMaster University, April 1 2018: <https://www.mcmasterforum.org/docs/default-source/product-documents/rapid-responses/supporting-professional-learning-approaches-to-foster-global-competencies-in-k-12-education.pdf?sfvrsn=2>

⁶¹ *Ibid.*

⁶² "Council of Ministers of Education Canada: Celebrating 50 years of Pan-Canadian Leadership in Education," CMEC, accessed June 2020: https://www.cmec.ca/11/About_Us.html

⁶³ Mattison C., Gauvin F., Waddell K. "Rapid synthesis: Supporting professional learning approaches to foster global competencies in K-12 education." Hamilton: McMaster Health Forum | Forum+, 1 April 2018: <https://macsphere.mcmaster.ca/handle/11375/23792>



The Student Learning Experience Technology Skills and Competencies

Educators, academics, and policymakers continually consider how new technologies (among other trends) will evolve the education system. Over the last 20-30 years, numerous frameworks have been developed to help guide these discussions on how best to ensure that students are prepared to meet challenges and prosper in both the economy and society more broadly. Examples of groups that have explored this area include the Partnership for 21st Century Skills (a non-profit coalition of industry, educators, and policymakers),⁶⁴ other large international organizations such as the OECD,⁶⁵ and larger strategic efforts from national or provincial governments.

These frameworks differ, however, there are areas of considerable overlap. This overlap is often referred to as the “future-oriented 21st century skills” (and competencies) necessary for students to succeed against a backdrop of new technologies and a myriad of global social, environmental, and economic challenges. Future oriented skill frameworks typically include critical thinking, problem solving, collaboration, creativity, adaptability, and communication.⁶⁶

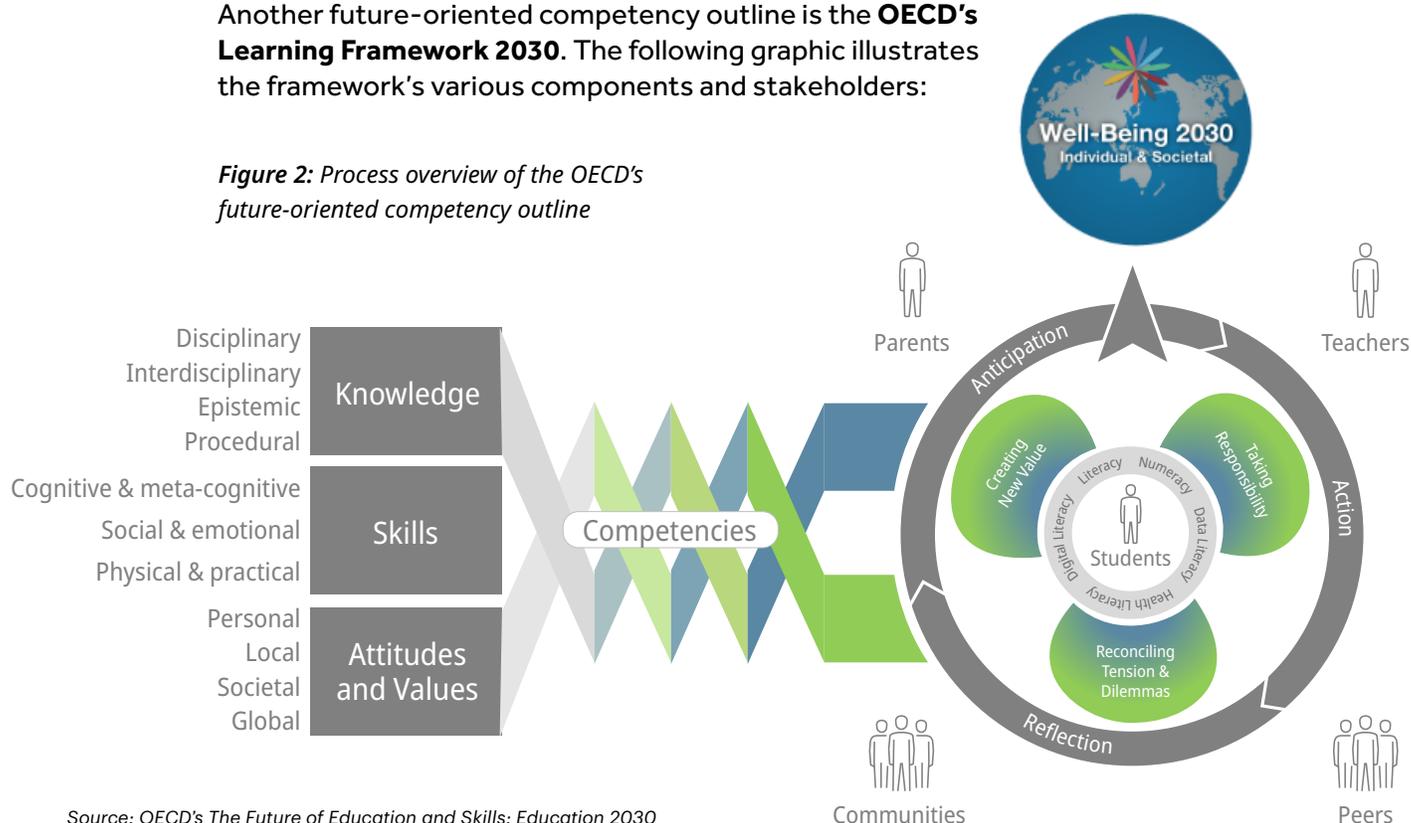
⁶⁴ Battelle For Kids, accessed June 2020: <https://www.battelleforkids.org/about-us>
“The Future of Education and Skills: Education 2030,” OECD, 2018:

⁶⁵ OECD, “The Future of Education and Skills: Education 2030”, 2018:
[https://www.oecd.org/education/2030/E2030%20Position%20Paper%20\(05.04.2018\).pdf](https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf)

⁶⁶ Conlon, K., “The Global Achievement Gap,” Harvard Graduate School of Education, August 20, 2008:
<https://www.gse.harvard.edu/news/08/08/global-achievement-gap>;

Another future-oriented competency outline is the **OECD's Learning Framework 2030**. The following graphic illustrates the framework's various components and stakeholders:

Figure 2: Process overview of the OECD's future-oriented competency outline



Source: OECD's *The Future of Education and Skills: Education 2030*



EU Digital Competencies

Likewise, the European Union has produced the Digital Competence Framework 2.0⁶⁷ outlined by The European Digital Competence Framework for Citizens, also known as DigComp.⁶⁸ According to DigComp 2.0, digital skills can be grouped into five categories which are listed below:

- 1 **Information and Data Literacy:** This includes browsing, searching, and filtering data and content as well as the ability to evaluate, analyze, and manage the data and digital content by organizing and storing it.
- 2 **Communication and Collaboration:** The ability to interact, communicate, and collaborate through digital technologies. Students accomplish this by sharing data, information, and digital content with others. It includes an awareness of behavioural norms, "Netiquette,"⁶⁹ and the ability to manage one's digital identity and reputation.

⁶⁷ *The Digital Competence Framework 2.0*, European Commission, accessed June 2020: <https://ec.europa.eu/jrc/en/digcomp/digital-competence-framework>

⁶⁸ Vuorikari, R. et al. "DigComp 2.0: The Digital Competence Framework For Citizens. Update Phase 1: the Conceptual Reference Model," European Commission, 2016: <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-20-digital-competence-framework-citizens-update-phase-1-conceptual-reference-model>

⁶⁹ According to Webroot.com, Netiquette is a combination of the words network and etiquette and is defined as a set of rules for acceptable online behavior.

- 3 Digital Content Creation:** Knowing how to develop and edit digital content in different formats. Understanding how to modify, improve and integrate information and content into an existing body of knowledge in order to create new content, as well as understanding and respecting copyright and licences. It also covers how to give understandable instructions to a computer system. This group of skills includes programming, which implies creating a sequence of instructions for a computing system with the aim of solving a given problem or performing a specific task.
- 4 Safety:** Implies understanding how to protect devices, digital content, personal data, and privacy in digital environments. Includes awareness of how to protect physical and psychological well-being and avoid health risks related to digital technology use. It also covers the awareness of digital technologies for social wellbeing and social inclusion, as well as having an awareness of the environmental impact of digital technologies.
- 5 Problem Solving:** Skills that include the ability to identify and solve technical problems with operating devices, the ability to assess needs and to use digital tools to solve them, and to resolve conceptual problems and difficult situations in a digital environment. It also includes the ability to use digital tools to create knowledge, innovate processes and products, and understand how to improve and update digital competencies. It entails seeking new opportunities for self-development to keep up with the digital world.

Future Ready Skills (21st Century Digital Skills)

ICTC also conducted primary research into the digital skills⁷⁰ or core competencies that are fundamental for student success after graduation.

Responses varied greatly between both technical and human skills (i.e., soft or transferable skills), which were categorized based on number of times mentioned. Respondents represented academia, industry, public policy, educational technology consultancy experts, and Indigenous education and skills development instructors from across Canada. Within these fields, ICTC interviewed a variety of K-12 educators, post-secondary instructors, educational policy experts, school administrators, ICT coordinators, C-suite industry executives, and learning consultants. The following results were aggregated from the 20 survey responses to show relative rankings of common themes based on the frequency in which they were mentioned:

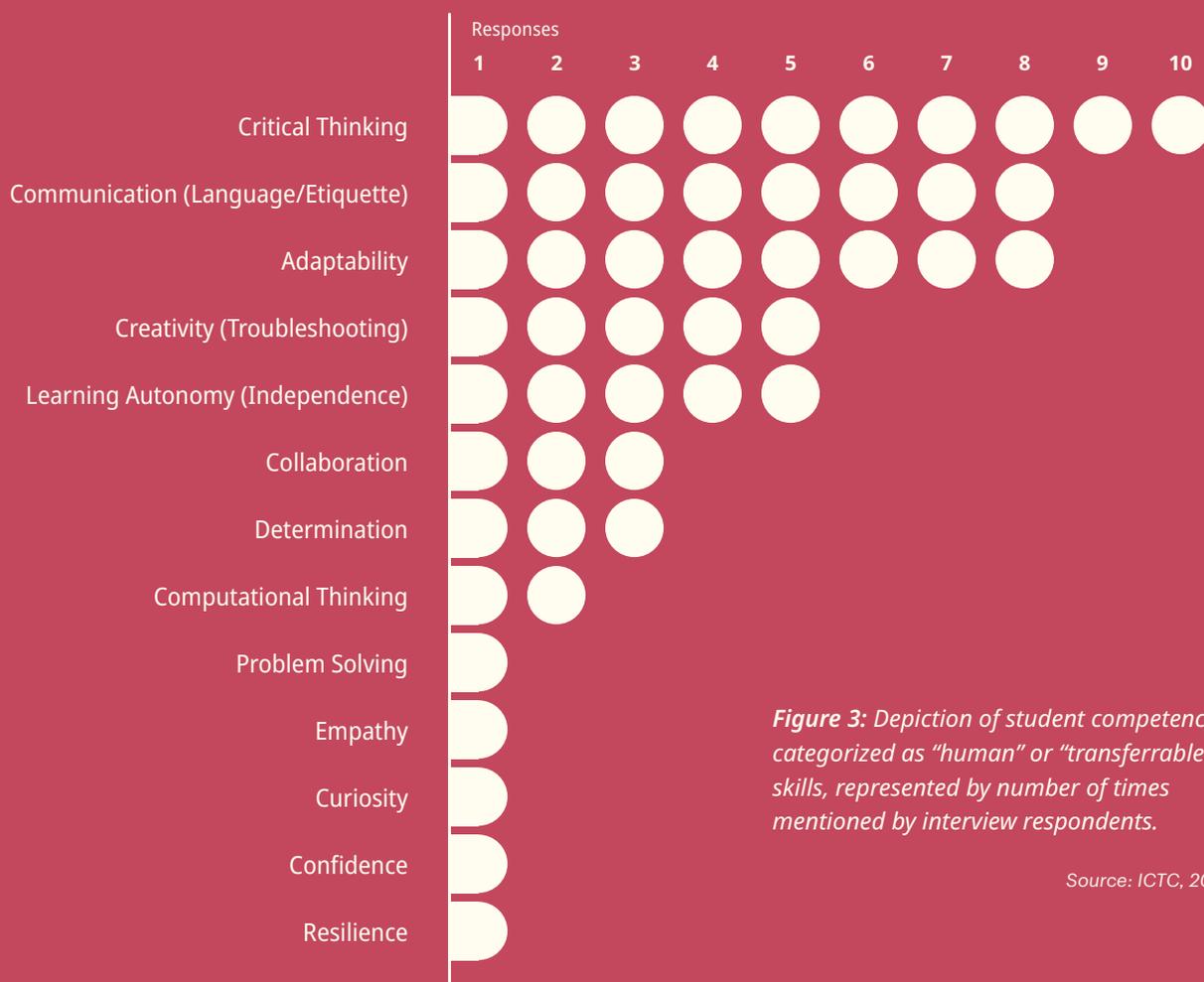
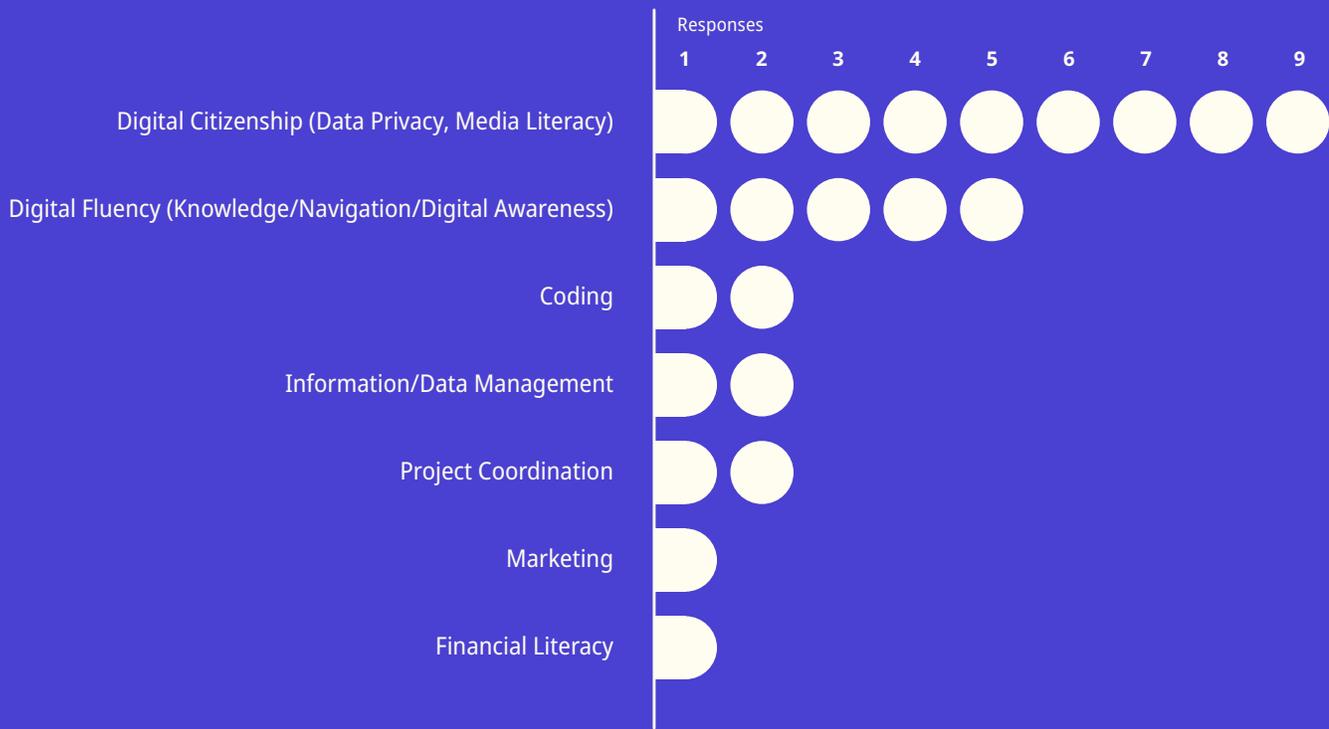


Figure 3: Depiction of student competences, categorized as “human” or “transferable” skills, represented by number of times mentioned by interview respondents.

Source: ICTC, 2020

⁷⁰ A more detailed explanation of technical skills or human skills/competencies can be found on page 16 of this report.

Figure 4: Depiction of student competences, categorized as “technical” or “academic” skills, represented by number of times mentioned by interview respondents.



Source: ICTC, 2020

Furthermore, one respondent highlighted the value of incorporating information literacy (media literacy) into the classroom as a way of better understanding context, bias, and misinformation. It was recommended that this be done symbiotically with core curriculum offerings to help encourage good digital citizenry.



Innovative Approaches to Tech Implementation in Canada

Canada's diverse communities and classrooms have led to many interesting examples of technology integration. Each province manages their own education systems and typically school boards and individual educators can experiment with technology integration. Despite the value of leveraging technology, it is worth noting that educators emphasize that technology is merely another tool for delivering education:

We're not here to teach the kids technology. We're here to use it as a tool to learn.

– Educator, Quebec

In addition to the specific technical knowledge gained using technologies, students are also able to develop the competencies identified by the EU's Digital Competence Framework 2.0. In this section we will identify how these technologies are tied together with skills and competency development.

Some of the different options that have been adopted are outlined below.

3D Printing

The ability for students to design and print items through 3D printing (sometimes more formally referred to as “additive manufacturing”) has received significant attention in education. Benefits include allowing students to be creative and develop design principles, while empowering teachers to create scenarios that help students learn from failures that are inherent in the experimentation process.⁷¹ In Alberta, students in Grade 10, 11, and 12 used desktop 3D printers to print and assemble fully functioning, custom-sized hands for children in developing countries. This helped students to learn about technology, prosthetics, medicine, and social consciousness.⁷² In British Columbia, students received acclaim for their 3D printing of healthcare supplies, which helped offset shortages.⁷³ One respondent noted that digital skills in 3D printing were particularly valuable for rural communities and regional industries. This educator highlighted that in certain Northern Canadian communities where industries such as mining are prevalent, early adoption of skills related to 3D printing could spur youth interest in mining and exploration at an early age—while learning the critical skills to be successful in other fields as well. An example is Yukonstructs,⁷⁴ an afterschool 3D printing programs and specialized curriculum designed by educators in Whitehorse.⁷⁵

Future Skills and Training Implications

Classroom 3D printing develops information and data literacy skills through searching and filtering data to find relevant files and instructions. Furthermore, there are also ties to communication and collaboration as these projects can be complex and require peer-to-peer learning. A strong digital content creation component is associated with design processes. But perhaps the most significant skill or competency is problem solving.

AI

As Artificial Intelligence (AI) continues to be adopted in the education system, “Applied AI” is helping to predict, analyze, and conduct tasks that normally require human input. In Canada, AI has improved and streamlined educational processes, including enhancing and automating administrative tasks, assisting teachers, and aiding in the creation of personalized learning experiences for students.⁷⁶

⁷¹ “Our list of the top 4 ways 3D printing is changing education,” *Print Your Mind 3D*, accessed June 2020: <https://www.printyourmind3d.ca/blogs/articles/4-ways-3d-printing-is-changing-education>

⁷² Annalise, K., “Alberta high school students to 3D print prosthetic hands for kids,” *Calgary Herald*, January 1, 2016: <https://calgaryherald.com/news/local-news/alberta-high-school-students-to-3d-print-prosthetic-hands-for-kids/>

⁷³ Ahearn, V., “Innovative B.C. Boy Scout prints ‘ear gears’ for surgical masks,” *Globe & Mail*, April 8, 2020: <https://www.theglobeandmail.com/canada/british-columbia/article-bc-boy-scout-printing-ear-gears-for-surgical-masks-during-covid-1/>

⁷⁴ Yukonstruct, “3D-Printing After-School Workshop,” February 25th, 2020: <https://yukonstruct.com/event/3d-printing-after-school-workshop/>

⁷⁵ Snider, M. “3D Printing” *Curriculum Technology Consultant*, Accessed November 2nd, 2020: <http://msnider.yukonschools.ca/3d-printing.html>

⁷⁶ Israelson D., “Where AI Could Take the Classroom,” *The Globe and Mail*, October 31st, 2018: <https://www.theglobeandmail.com/canada/education/canadian-university-report/article-where-ai-could-take-the-classroom/>

Globally the U.N. Educational, Scientific and Cultural Organization (UNESCO) reports that approximately 1.37 billion students were out of school as of March 24, 2020⁷⁷ and hundreds of millions of students continued their education online. Advancements in AI present new opportunities to assist this digital transition. In Canadian curriculum, AI has numerous moral and ethical implications.⁷⁸ The following represents a few interesting examples of how AI is being applied in education.

Smart Content

This technology helps to disseminate, breakdown, and condense textbook content into a digestible and useful digital study guide that includes chapter summaries, multiple choice practice tests, etc. Several companies, such as Cram101 and JustTheFacts101, are among the leaders that are demonstrating the potential of this technology for various grades in K-12 and higher learning.⁷⁹

Intelligent Personalized Tutoring Systems

These systems deliver customized learning experiences tailored to the diverse learning styles and preferences of each individual student. While online learning allows students to continue their education from home and communicate with teachers and peers, the use of AI could be a beneficial tool in augmenting the effectiveness of digital learning. Intelligent Personalized Tutoring technologies offer a more personalized experience for each student by streamlining material best suited to their capability. AI analyzes the child's understanding, their preferred method of learning, and their experience, all of which have been previously programmed into the system. Doing so allows students to receive a unique and personalized learning experience, helping them achieve better academic results.

Example



British-based Century Tech developed an AI-driven learning platform for schools that is adaptive, interactive, and science-based. It combines neuroscience and AI to individualize learning. Since February 2020, the for-profit Century Tech platform has made its platform temporarily free for schools in 17 countries, including China, Vietnam, South Korea, Japan, the UK, Nigeria and Georgia.⁸⁰

⁷⁷ "1.37 billion students now home as COVID-19 school closures expand, ministers scale up multimedia approaches to ensure learning continuity," UNESCO, March 24, 2020: <https://en.unesco.org/news/137-billion-students-now-home-covid-19-school-closures-expand-ministers-scale-multimedia>

⁷⁸ "IDC4U Interdisciplinary Studies: Artificial Intelligence – Grade 12 (University)," Blyth Academy, Accessed November 2020: <https://blytheducation.com/blyth-academy-online/courses/idc4u-artificial-intelligence/>

⁷⁹ Faggella, D., "Examples of Artificial Intelligence in Education," EMERJ, Nov 21, 2019: <https://emerj.com/ai-sector-overviews/examples-of-artificial-intelligence-in-education/>

⁸⁰ Anderson, J., "The Coronavirus Pandemic is Reshaping Education," QUARTZ, March 29th, 2020: <https://qz.com/1826369/how-coronavirus-is-changing-education/>

The opportunity to utilize AI and Machine Learning (ML) was cited by two respondents who highlighted both the value and risks of their impact on the contemporary student learning experience. Individualized learning opportunities that track and evaluate competencies and habits related to mathematics and literacy are considered net positives. However, the concept of funnelling specific information (i.e., content, lessons, etc.) is considered by some respondents to be too restrictive and narrow focused, limiting the student's ability to explore new topic areas. Furthermore, the use of AI brings potential risks associated with privacy and youth surveillance.

Future Skills and Training Implications

The utilization of various AI technologies involves information and data literacy skills (to understand how these tools operate), digital content creation skills (including understanding of computer instructions and how to perform tasks), safety skills (understanding the risks and threats for privacy and negative social impacts), and problem-solving skills (how to use these tools practically.)

VR/AR/XR Technologies

VR/AR/XR introduces immersive learning and provides engaging real-life experiences that would otherwise be dangerous or inaccessible to students. This popular learning method has been particularly well received by students who are “visual learners” and prefer visual and tactile experiences, as opposed to traditional modes of learning. A popular form of VR technology provides digital field trips which allow students to experience ancient worlds, ocean floors, and the world's highest mountains. Google, Apple, zSpace, Nearpod VR, Merge, Discovery VR, Alchemy VR, EON Reality, Unimersiv and Curiscope⁸¹ are leading these experiential learning opportunities, pushing the boundaries of VR/AR/XR education. VR/AR/XR technologies are also useful for future employment, as noted in this interview:

Skills for advanced manufacturing, for example, or health services, seem to be keen on the idea of VR or AR. This is likely because it has the ability of enhancing an experience by telling you what you know, what you need to know or giving you the chance to work on something new first-hand—so maybe doing a virtual brain surgery before you actually open up somebody's head. ■■

– CEO, Educational Technology, Manitoba

⁸¹ Burch, A., “The Top 10 Companies Working on Education in Virtual Reality and Augmented Reality [Rebooted],” Touchstone Research, April 9, 2019: <https://touchstoneresearch.com/the-top-10-companies-working-on-education-in-virtual-reality-and-augmented-reality-rebooted/>

Apple's Commitment to Augmented Reality (AR) for Education

Standing proudly behind the power, functionality and popularity of their versatile iPad device, Apple's commitment to augmented reality technologies continues to increase. For educators, this commitment provides engaging lesson opportunities for students with educational applications that harnesses existing curriculum.⁸² Apple highlights their AR application library which features programs such as Measure and GeoGebra Augmented Reality which are mathematics-focused programs with immersive features that allow students to engage with more abstract concepts.⁸³ Leaning on the power and speed of their recent iPad generation, their AR application library leverages the device's accelerometers, motion sensors and high resolution cameras.⁸⁴

Google Expeditions and Merge Cube

Google Expeditions has 900 VR experiences readily available to students which provide the tools necessary to create and design immersive VR expeditions using Google's customized editing software.⁸⁵ Merge Cube is also a leading example of VR/AR educational technology. The product caters specifically for youth aged 10 and older. Merge Cube aims to improve student intelligence, creativity, and collaboration by providing a patterned foam cube object. When scanned with an app, the cube "transforms" into an interactive augmented reality experience. This hand-held 3D hologram environment provides the user with the opportunity to explore objects like the human heart, an aquarium, or elements of the solar system.

Future Skills and Training Implications

VR/AR and XR technology comes with fine motor skills and physical safety implications. Researchers continue to examine the psychological impacts of immersive tech and its responsible use.⁸⁶ VR/AR experiences, however, can improve student problem solving capabilities by identifying and solving both technical and theoretical challenges.

⁸² "Augmented Reality in Education: Lesson Ideas", Apple 2019, accessed January 2021: <https://www.apple.com/tr/education/docs/ar-in-edu-lesson-ideas.pdf>

⁸³ *Ibid.*

⁸⁴ *Ibid.*

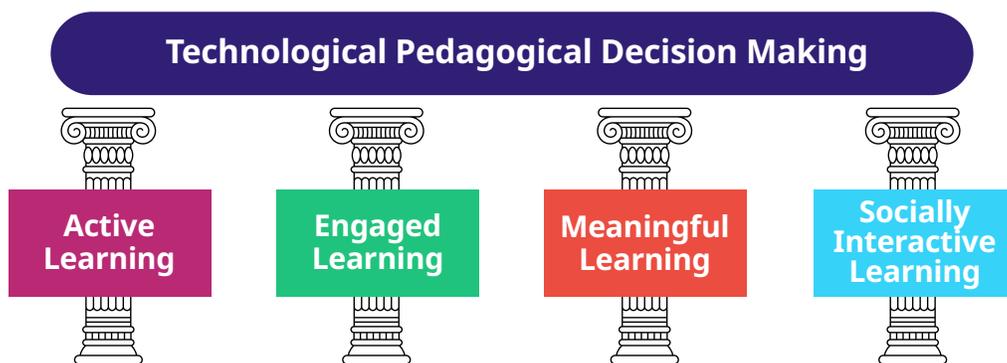
⁸⁵ Burch, A., "The Top 10 Companies Working on Education in Virtual Reality and Augmented Reality [Rebooted]."

⁸⁶ "Gauging the long-term impacts of augmented and virtual reality," Verdict, July 9, 2019: <https://www.verdict.co.uk/ar-and-vr-psychological-effects-2019/>

Education Apps

ICTC research indicates that the proliferation of education apps can be overwhelming for teachers. Over 80,000 apps are readily available⁸⁷ and, with significant adoption of mobile devices in the classroom, this has driven a “shift in the pedagogical approach to media and technology.”⁸⁸ Given the abundance of options, this can be an exceptionally difficult issue for teachers that often results in challenging choices and a struggle to find a group consensus on what provides the “best solution.” Research has developed frameworks that help guide educators when considering their options. The two-option model presents “open and closed” categories: “open” apps that allow students to participate as creators, and “closed” apps that teach more traditional literacy and numeracy skills. There are also more complex models that break down the options into four pillars:

Figure 5: Technological Pedagogical Decision Making



Source: Hirsh-Pasek et al. (2015) Four Pillar Model

Active Learning refers to active exploration, where effort and learning should be purposeful rather than “mindless.” Engaged Learning involves three different kinds of engagement: behavioural, emotional, and cognitive. Often this involves a trade-off of engagement as opposed to distraction. Meaningful Learning in this context refers to apps that make material relevant to the learner in real-life scenarios (as opposed to rote memorization). Lastly, Socially Interactive Learning refers to language learning and understanding or face-to-face interactions.⁸⁹

Future Skills and Training Implications

As apps are increasingly embedded in our lives, students will need to navigate the responsible usage of digital tools. They develop numerous skills such as: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving.

⁸⁷ Shing, S. and Yuan B., “Apps Developed by Academics,” *Journal of Education and Practice*, ISSN 2222-1735 (Paper) ISSN 2222-288X (Online) Vol.7, No.33, 2016: <https://files.eric.ed.gov/fulltext/EJ1122634.pdf>

⁸⁸ “How to Choose an Educational App,” *Canadian Teacher Magazine*, Sept 2017: <https://canadianteachermagazine.com/2017/09/15/how-to-choose-an-educational-app/>

⁸⁹ “How to Choose an Educational App,” *Canadian Teacher Magazine*

Gamification and Games-Based Learning (GBL)

Gamification and Games-Based Learning (GBL) in K–12 integrates interactivity into the education process, and introduces an element of entertainment into lessons, potentially leading to a more engaging and memorable educational experience. Gamification and GBL, when used properly, is proven to enhance student engagement, motivation, flexibility, and collaboration while building and promoting digital skills.⁹⁰ Games that incorporate tasks (“quests”), varying difficulty levels, challenges, and rewards provide a natural way for educators to engage students and turn learning into play.

Gamification and GBL are similar in that both strategies promote engagement and motivation to learn. However, gamification and game-based techniques have unique nuances. Gamification integrates elements such as point-based systems, leaderboards, badges or other elements⁹¹ while game-based learning is training that uses game elements to teach a specific skill or achieve a specific learning outcome (it takes core content and objectives and makes them fun).⁹² Teachers are utilizing popular video games like Roblox and Minecraft to demonstrate scientific principles like climate change or cellular biology.⁹³ These games introduce elements such as “education mode,” which provide unique in-game learning opportunities.

Like VR, Games-Based Learning can be applied to history lessons and used to digitally tour and explore ancient worlds. As an example, Ubisoft’s “Assassin’s Creed: Odyssey” allows students to explore ancient Greece along with several historical landmarks. During its development, Ubisoft teamed up with Canadian historians to recreate ancient Greece and ensure locations, politics, landscapes and the overall “feel” held true to the period. Ubisoft included a robust “education mode,” repurposing the game for educational purposes.⁹⁴

Videogames and the principle of gamification in education was highlighted by interview respondents as an opportunity to create and foster virtual communities for youth. One interviewee noted that videogame environments can be a valuable venue for connecting with friends and family virtually in a shared and recreational space during the pandemic.

⁹⁰ Fortier, M., “The Power of a Gamified Classroom,” *Technology and Curriculum*, Accessed June 2020: <https://techandcurr2019.pressbooks.com/chapter/gamified-classroom/>

⁹¹ “Gamification and Game-Based Learning,” University of Waterloo Centre for Teaching Excellence, Accessed June 2020: <https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/educational-technologies/all/gamification-and-game-based-learning>

⁹² “Gamification and Game-Based Learning,” University of Waterloo Centre for Teaching Excellence

⁹³ Favis, E. “With coronavirus closing schools, here’s how video games are helping teachers,” *Washington Post*, April 15, 2020: <https://www.washingtonpost.com/video-games/2020/04/15/teachers-video-games-coronavirus-education-remote-learning/>

⁹⁴ *Ibid.*

Future Skills and Training Implications

Gamification and Games-Based Learning develops information and data literacy skills, including the ability to navigate and analyze information and digital content. Communication and collaboration skills are also fostered when there is a need to interact, communicate, and collaborate in “quests,” especially as a team. Strong digital content creation and problem-solving skills are also required when designing, creating or building within a game.

Learning Management Systems (LMS): Educational Process Mapping

Learning Management Systems (LMS) have transformed the traditional educational experience by designing digital learning environments that augment or reshape the classroom experience. The presence of LMS tools such as Google Classroom, Canvas, Moodle, D2L, Blackboard, and Canvas are becoming better known outside of their traditional post-secondary homes, and are moving into K-12 learning, partially as a result of the pandemic. Leading-edge LMS tools provide users with more than the opportunity to design and deliver customized curricula, facilitate testing, showcase multimedia materials, and engage users in interactive experiences;⁹⁵ they have also expanded the ability to detect certain learning challenges among their users.

As LMS expands in usage and functionality, the application of advanced data science techniques also increases. Process mining, which provides “fact-based insights,” offers a deeper user and system experience, combines big data and data mining techniques.⁹⁶ Process Mining also combines elements of process-analysis with the integration of machine learning and data mining that analyze nuanced user behaviour.⁹⁷ This process is used in Educational Process Mining, which produces data that allows educators and administrators to identify a student’s underlying learning experience and generates recommendations and advice. It can also provide insights for parents and educators on their child’s academic progress to improve student learning.⁹⁸

Future Skills and Training Implications

Given the significant role of LMS systems in education, unsurprisingly it has implications across numerous skills and competencies such as information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. It is worth noting that it is particularly important for students to become skilled with LMS technologies as the workload of online learning increases. Training for future careers could also be delivered through similar LMS platforms.

⁹⁵ “TechnologyAdvice Learning Management Systems Buyer’s Guide,” *Technology Advice*, June 3 2020: <https://technologyadvice.com/learning-management-systems/>

⁹⁶ Karwowski, W., Ahram, T., “Proceedings of the 1st International Conference on Intelligent Human Systems Integration (IHSI 2018): Integrating People and Intelligent Systems,” January 7-9, 2018 https://books.google.ca/books?id=N-IEDwAAQBAJ&pg=PA421&lpg=PA421&dq=Learning+Management+Software+detects+learning+disability&source=bl&ots=KqtF9hVvmP&sig=ACfU3U2_bee59ZlJa7JAxB6wJTOLbrWEGQ&hl=en&sa=X&ved=2ahUKEwiru8XCsoHhAhUjZn8KHxSSADIQ6AEwBH0eCEDEQAQ#v=onepage&q=Learning%20Management%20Software%20detects%20learning%20disability&f=false Pg 421

⁹⁷ *Ibid.*

⁹⁸ *Ibid.*



Procurement and Technology Integration

When considering classroom technology adoption, it is critical to also explore the related issues of procurement and roll-out. While important and broad-sweeping issues impact school purchasing policies at large, this paper primarily focuses on an individual level of procurement by educators (rather than at a provincial or district level).

As noted in previous ICTC research on K-12 education technology, procurement remains a barrier for the widespread adoption of technology in schools. However, there are continuing developments in this area that can help address these challenges. One example from ICTC interviews is Ontario's test pilot to allow schools to try new technology projects thanks to "seed funding." Educators viewed this positively. Other directions for improvement noted by education experts were consistent funding opportunities for up-to-date software, the loosening of antiquated restrictive policies, and the implementation of open-source software to remedy historical challenges around costs, accessibility, and adoption.

Furthermore, respondents emphasized the need for technology support specialists for identifying, sourcing, and providing the roll-out strategies of new technologies. This includes training, ongoing support and the coordination of professional development opportunities.

Non-profit organizations such as “Let’s Talk Science” were noted for their offer of free professional learning days to help educators learn new digital skills. One interviewee pointed out that professional learning groups and educator committees were also helpful in connecting with groups of 25-40 educators. The Apple Distinguished Educator Program was highlighted by an education consultant from the Canadian territories: “[It’s a] network of dozens of people from across the country for idea sharing, trends and what’s happening, which I can then take and bring back [North] with me.”

Over the past 20 years several technology integration models have been developed and leveraged by educators across Canada. Some of these include: LoTi, TPACK, RAT, TAM, TIM, TIP, HACK, PICRAT, SAMR, and PICRAT. Although some of these examples remain popular and widely used to this day, others have become overly specialized or redundant due to various advancements in technology. In this study we provide a brief overview of two of the contemporary and widely used adoption models for educators and administrators in Canada. This includes SAMR, as well as the more recent model referred to as PICRAT.⁹⁹

SAMR Model

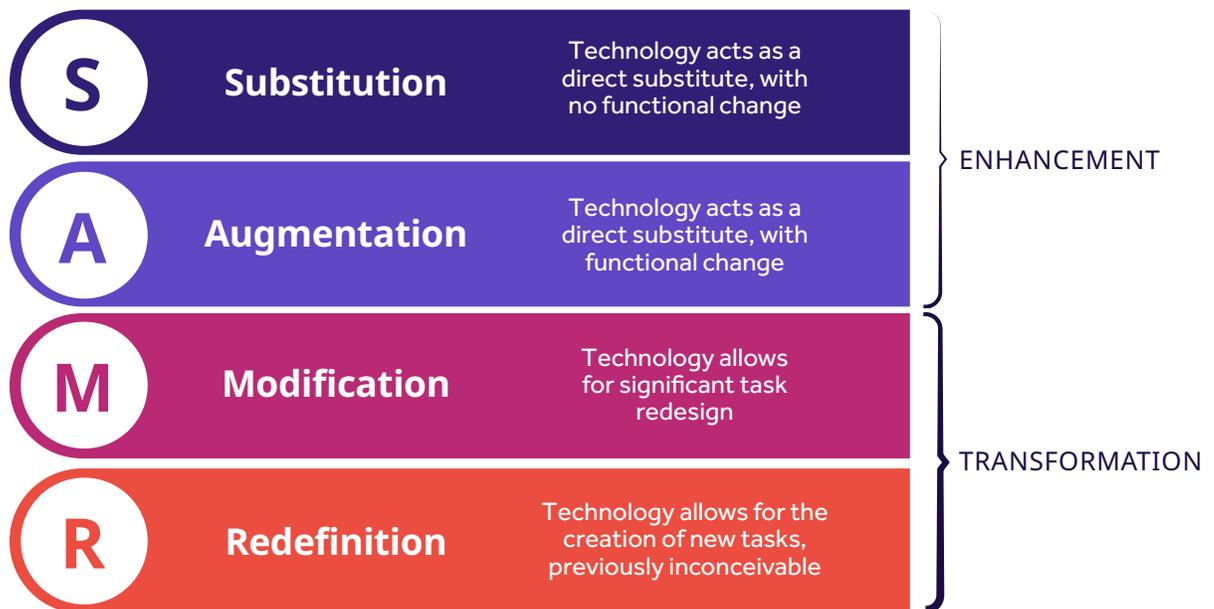
Interview respondents recognized the popularity of the SAMR Model (Substitution, Augmentation, Modification, and Redefinition) in schools and administrations. This model is helpful for classifying and understanding how digital technologies can be used in the classroom so that educators fully utilize their capabilities. This section will provide a brief description of how the SAMR Model fits into K-12 education.

The SAMR model provides a four-level conceptual framework for the impact of technology on teaching and learning. It was developed to share a common language across disciplines as teachers strive to help students visualize complex concepts.¹⁰⁰

¹⁰⁰ Kimmons, R., Graham, C. R., & West, R. E., “The PICRAT model for technology integration in teacher preparation. *Contemporary Issues in Technology and Teacher Education*,” 2020. <https://citejournal.org/wp-content/uploads/2020/02/v20i1general2.pdf>

¹⁰¹ “SAMR Model: A Practical Guide for EdTech Integration,” *schoolology exchange*, Oct 30, 2017: <https://www.schoolology.com/blog/samr-model-practical-guide-edtech-integration>

Figure 6: The SAMR model



Source: Creative Commons

The Four Levels of SAMR

S **Substitution:** This refers to technology acting as a direct substitute to pre-existing tools with no *functional change*—in other words, a simple replacement. Examples include typing notes on a laptop as opposed to writing on paper or reading an electronic document in place of a physical book. Despite its simplicity, “substitution” of technology may still benefit educators by reducing repetitive tasks. It can also provide students a more accessible introduction to technological skills.¹⁰²

A **Augmentation:** This refers to the usage of technology where it still acts as a direct substitute to pre-existing tools, but with *functional improvements*. Educators need to consider whether technology usage increases the student’s productivity or potential. Notably, augmentation builds on an *existing way of learning*; the digital technology is not required to perform tasks but simply provides a new medium that may enhance learning¹⁰³ by helping students better understand a complex topic or make it more engaging.

¹⁰² “The SAMR Model Explained (With 15 Practical Examples),” 3plearning, accessed Oct 2020: <https://www.3plearning.com/blog/connectingsamrmodel/>

¹⁰³ Fastiggi, W., “The SAMR Model,” Technology for Learners, accessed Oct 2020: <https://technologyforlearners.com/the-samr-model/>

An example is creating an electronic document but also enhancing its functionality with embedded hyperlinks, predictive text-editing, search functionality, or spellcheck features. Other examples would include enhancing a presentation with an embedded video or the use of gamified electronic quizzes that have additional features over traditional paper quizzes.¹⁰⁴

M **Modification:** This refers not only to enhancement but also transformation of existing learning techniques, lesson designs, and learning outcomes. Educators should consider that modification significantly alters the task.

For example, this could include students setting up a blog to access a global audience, which would require students to be more accountable for their work as they refine it for public consumption (improving literacy and student learning). Other examples are Learning Management Systems that provide new ways of delivering classroom logistics, text chats or web forums that allow asynchronous communication among students.

R **Redefinition:** This level of technology adoption requires teachers to think about activities that were not previously conceivable. It is the “pinnacle” of how tech can transform learning for the student. This type of technology could redefine a task in a way that traditionally would have been impossible, creating a novel experience. Examples include virtual interactive fieldtrips of ancient civilizations or digitally connecting with authors of the books studied in the classroom.

The SAMR Model in the Classroom

The SAMR Model can act as a useful planning tool for educators because this framework helps design better learning activities by understanding how tech can and should be used in classroom. During the early years of technology adoption in the classroom (and the transition to online learning environments), teachers “often focused on the first two levels, which involve replacing traditional materials with digital ones, converting lessons and worksheets into PDFs and posting them online or recording lectures on video and making them available for asynchronous learning.”¹⁰⁵ As educators become more comfortable with embedding digital technologies into the teaching process, there are more significant opportunities: “In classrooms where tech integration has moved to the mastery level, the last two levels of the SAMR model—modification and redefinition—should also be in the mix.”¹⁰⁶

¹⁰⁴ Terada, Y., “A Powerful Model for Understanding Good Tech Integration,” *Edutopia*, May 4 2020: <https://www.edutopia.org/article/powerful-model-understanding-good-tech-integration>

¹⁰⁵ Terada, Y., “A Powerful Model for Understanding Good Tech Integration,”

¹⁰⁶ *Ibid.*

This model is often visualized as a ladder, however, this is misleading. It may be better to consider the SAMR model as a “spectrum” that from simple replacement of traditional tools on the one end and enabling experiences that would otherwise be impossible without technology on the other.¹⁰⁷ Educators should consider whether their teaching needs require more technology. As some education experts suggest that, for effective technology integration, “the goal isn’t to use the most sophisticated tool, but to find the right one for the job.”¹⁰⁸

PICRAT

The PICRAT model consists of two parts, PIC (Passive, Interactive and Creative) and RAT (Replace, Amplify and Transform) while considering two dimensions: a students’ relationship to the technology (PIC) and the teacher’s use of the technology (RAT).¹⁰⁹

This framework considers the intersection of these two dimensions. The two-part PICRAT matrix represents various squares, each representing a different use of technology from both the student and teacher’s perspective. The matrix is designed to assist educators in reflecting on their teaching styles, pedagogy and ideally, their journey towards creative and transformative practice (CT). The philosophy surrounds students adopting an engaged, and creatively dynamic learning experience supported by technology.¹¹⁰

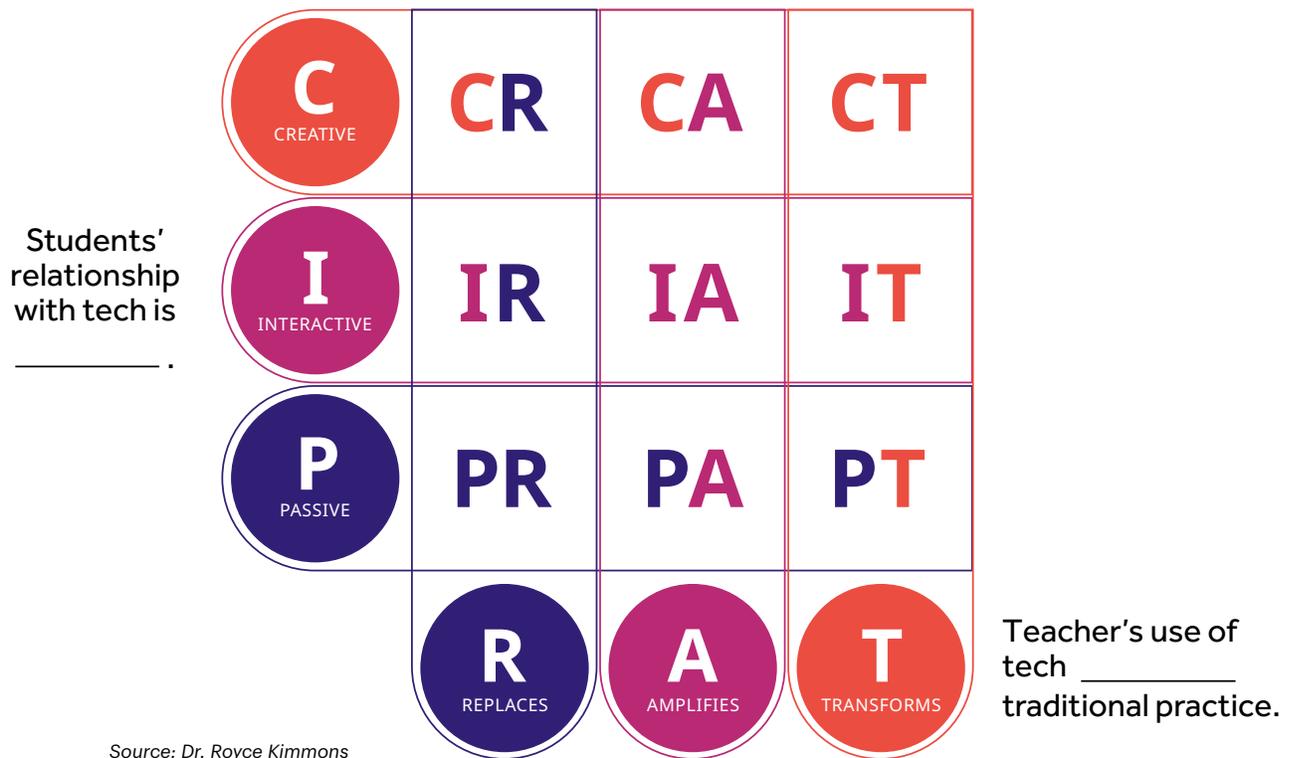
¹⁰⁷ SAMR Model: A Practical Guide for EdTech Integration,” schoology exchange

¹⁰⁸ Terada, Y., “A Powerful Model for Understanding Good Tech Integration.”

¹⁰⁹ Kimmons, R., Graham, C. R., & West, R. E., “The PICRAT model for technology integration in teacher preparation. *Contemporary Issues in Technology and Teacher Education*,” 2020. <https://citejournal.org/wp-content/uploads/2020/02/v20i1general2.pdf>

¹¹⁰ *Ibid.*

Figure 7: The PICRAT matrix



Category Descriptions

PIC: Refers to a student's inherent use of technology in their learning experience.

Passive: Refers to students that are being passive receivers of information.



Example: watching a YouTube video.

Interactive: Occurs when students are receiving information and interacting with technology in order to respond to the information received.



Example: completing a digital homework assignment.

Creative: Occurs when students are using the technology to create learning products that represent their understanding of new material, a synthesis of new information and problem solving.

RAT: Refers to a teachers' use and/or application of technology.

Replacement: Occurs when technology is used to replace traditional methods of teaching and learning, but does not fundamentally change the nature of the lesson itself.

Amplification: Refers to the use of technology as an additive element that aims to improve the efficiency of tasks or introduces new functions.

Transformation: Occurs when new activities are introduced to a lesson plan that are explicitly dependent on the use of technology.



Example: a teacher uses a PowerPoint presentation instead of writing on a whiteboard.



Example: adding a recording of a student's voice to a presentation, or using proof-reading tools in MS Word.



Example: making a video and posting it online, recording a podcast or publishing research findings as a digital infographic.





Technology as a Pillar of Education Policy

Education technology has tremendous potential to provide new learning opportunities while furthering Canada's educational values of equity, diversity, and a free and widely accessible public education system. The adoption of digital technology, however, has both positive and negative implications. It democratizes and spans physical distances between schools and communities. But for students and teachers without access to computers and connectivity, it can further isolate or disrupt the learning journey. Connectivity provides access to online content and respected educators around the world. Scalable digital technology often makes information free or available at low cost.¹¹¹ Some content has moved into public domains and open-source formats, promoting accessible education (for example Open Educational Resources), with few if any restrictions.¹¹²

As digital technologies have been adopted in classrooms across Canada, concerns are raised over issues of accessibility and the need to ensure that households or communities are not left behind.¹¹³

The beauty of technology is that it provides the ability [for students] to go to school anywhere, from anywhere. A student could have a disability and be located where certain opportunities are unavailable. Technology allows them to participate in a new and unique way. They could live in the rural Canada, but take a degree in the United States - just so long as they have broadband connection. ▀ ▀

- Higher Learning Indigenous Career Consultant, Ontario

¹¹¹ Lynch, M., "5 Ways that Edtech is Democratizing Education," *The Tech Advocate*, Feb 1, 2018: <https://www.thetechadvocate.org/5-ways-edtech-democratizing-education/>

¹¹² "Open Educational Resources (OER)," UNESCO, Accessed June 2020: <https://en.unesco.org/themes/building-knowledge-societies/oer>

¹¹³ Van Dijk, J., "Closing The Digital Divide: The Role of Digital Technologies on Social Development, Well-Being of All and the Approach of the Covid-19 Pandemic," University of Twente (NL) - the United Nations, July 22, 2020: <https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/07/Closing-the-Digital-Divide-by-Jan-A.G.M-van-Dijk.pdf>

ICTC has discussed these issues in a previous report on the impact of technology on teaching and learning in Canada, but COVID-19 has brought them to the forefront.¹¹⁴ The shift to online and blended learning has often been welcomed, but not all Canadians have reliable and affordable access to broadband, resulting in a lack of opportunity to participate.¹¹⁵ Similarly, the growth of technology in education has placed significant financial burden on families, educators and their schools. Given the cost of procurement and operating costs across provinces and school districts, both one-to-one and bring-your-own-device (BYOD) offer trade-offs.¹¹⁶

As equity issues are clearly at the forefront of these discussions, it is important to acknowledge the opportunities presented by classroom technologies to assist students who are currently underrepresented. If implemented properly, educational technology can be leveraged by educators and administration to help address social and access inequities, both at the household and regional levels (including remote, rural, and Indigenous communities). As an example, one respondent noted that Indigenous students could remain within their communities in rural or remote areas without having to leave to pursue secondary or post-secondary education. Without proper consideration of equity and connectivity, however, remote and/or Indigenous communities could be disproportionately isolated from the benefits of edtech innovations.¹¹⁷

Gender Diversity

Several cross-national skills assessments have determined that those who self-identify as women are 25% less likely to leverage basic digital literacy skills for practical purposes and advancing their own wellbeing.¹¹⁸ UNESCO suggests that as the complexity of digital skills increases, those who identify as men are four times greater to succeed in highly technical areas.¹¹⁹ In North American tech hubs such as Silicon Valley, so few females apply for data science and artificial intelligence roles that talent scouts estimate women represent less than 1% of the available talent pool.¹²⁰ Those living in rural or remote access regions, in low income families or households that identify as visible minorities, have these challenges are magnified.

¹¹⁴ Modjeski, M., "Father says lack of internet access at rural home hurting daughters' education," CBC News, April 6, 2020: <https://www.cbc.ca/news/canada/saskatoon/remote-access-education-challenges-1.5522874>

¹¹⁵ "Students lacking Wi-Fi access told to head to school parking lots as 'last resort'", CBC News, April 7, 2020: <https://www.cbc.ca/news/canada/ottawa/thousands-families-lack-technology-as-schools-move-e-learning-1.5523219>

¹¹⁶ Ivus, M., Quan, T., Snider, N., "Class, take out your tablets: The impact of technology on learning and teaching in Canada" (January 2020). Information and Communications Technology Council: https://www.ictc-ctic.ca/wp-content/uploads/2020/04/ictc_impact-of-tech-on-learning-teaching-canada_final_en.pdf

¹¹⁷ "High-Speed Access for All: Canada's Connectivity Strategy," Innovation, Science and Economic Development Canada. Accessed November 2020: https://www.ic.gc.ca/eic/site/139.nsf/eng/h_00002.html

¹¹⁸ "Policy Paper- Rationales and Recommendations for Gender-Equal Digital Skills Education," UNESCO, Accessed June 2020: https://unesdoc.unesco.org/in/documentViewer.xhtml?v=2.1.196&id=p::usmarcdef_0000367416&file=/in/rest/annotationSVC/DownloadWatermarkedAttachment/attach_import_4338b69e-3819-45b8-b631-92b421978168%3F_%3D367416eng.pdf&locale=en&multi=true&ark=/ark:/48223/pf0000367416/PDF/367416eng.pdf#%5B%7B%22num%22%3A17%2C%22gen%22%3A0%7D%2C%7B%22name%22%3A%22XYZ%22%7D%2C0%2C842%2Cnull%5D

¹¹⁹ Ibid.

¹²⁰ Ibid.

As infrastructure continues to improve and becomes more readily accessible at lower costs, the gender disparity issue becomes more complex in various regions throughout the world. In Brazil, India and some Middle Eastern countries, for example, the primary deterrent to online networking and continued learning for women is a lack of opportunity for digital skill advancement.¹²¹ Women and girls in these regions also face digital and physical safety challenges, with higher rates of violence and exploitation.¹²² Violence against girls in a digital context includes harassment, stalking, bullying, threats of sexual violence, death threats, and unlawful surveillance.¹²³ An international report surveying over 4,000 women found over 900 respondents had experienced digital violence/harassment, with 61% of these women reporting lower self-esteem, motivation, and confidence as an outcome. Some 55% of these women experienced stress, anxiety, and panic attacks due to digital violence.¹²⁴

Nonetheless, technology and core digital literacy skills have the capacity to address the gender digital divide and improve access to education. The United Nations recognizes that technology plays a fundamental role in the development of a girl's ability to exercise her fundamental human rights, including her full, equal, and effective participation in cultural, economic, and political life.¹²⁵ The OECD suggests that connectivity and a commitment to technology training for young women and girls leads to higher levels of education and better careers.¹²⁶ Additional benefits include greater access to healthcare information (medical treatments and prescriptions), reduced risks of unwanted pregnancy, and improved access to career opportunities.¹²⁷ To address gender equity challenges within the tech community, leaders have begun developing educational organizations that specialize in female tech advocacy.¹²⁸ Organizations such as hEr VOLUTION, Canadian STEM Femmes, Up+Go, and TechGirls Canada assist those who identify as young women, girls, and those in the LGBTQ+ community cultivate technical skills, confidence, and leadership fundamentals through various programs and digital mentorships.

¹²¹ *Ibid.*

¹²² "Bullying statistics and facts," *Our Kids*, Accessed June 2020: <https://www.ourkids.net/bullying-facts-statistics.php>

¹²³ Duggan, M., "Online Harassment," *Pew Research Centre*, Oct 22, 2014:

<https://www.pewresearch.org/internet/2014/10/22/online-harassment/>

¹²⁴ "Harcèlement en ligne : l'impact inquiétant," *Amnesty International*, November 19, 2017:

<https://www.amnesty.fr/discriminations/actualites/des-femmes-du-monde-entier-font-etat-de-stress-dangoisse>

¹²⁵ UN General Assembly, "Human Rights Council Thirty-eighth session

18 June–6 July 2018," https://ap.ohchr.org/documents/E/HRC/d_res_dec/A_HRC_38_L6.docx Pg. 2

¹²⁶ "Bridging the Digital Gender Divide: Include, Upskill, Innovate," *OECD*, 2018:

<http://www.oecd.org/internet/bridging-the-digital-gender-divide.pdf> - Pg. 37

¹²⁷ *Ibid.*

¹²⁸ Bidshahri, R., "How technology is helping close the gender gap and empower women," *Singularity Hub*, July 29, 2018: <https://singularityhub.com/2018/07/29/how-technology-is-helping-close-the-gender-gap-and-empower-women/>

Cultural Diversity

Diversity is a major component of Canada's educational reality and is being addressed by culturally inclusive material. For example, in Saskatchewan technology is being used to include Indigenous lessons into curricula, and apps and tablets are bolstering Indigenous language learning.¹²⁹ Other research has examined diversity in Canadian classrooms and the challenges and opportunities for ensuring culturally responsive education programs along with the appropriate professional development for teachers.¹³⁰ Research increasingly highlights the need to recognize and integrate immigrant parents' experiences into student learning,¹³¹ while other studies consider visible and non visible issues of diversity such as economic status, academic issues, mental health issues, and sexual orientation.¹³² The benefits of allowing students to connect with other underrepresented peers was also highlighted by interview respondents:

 *The beautiful thing about the internet is that it manages to find small pockets of people who feel very isolated and allows them to come together in a common forum and to meet each other. It allows areas of our culture that are often in the fringes to become visible and then even become part of the mainstream.* 

– Educator, New Brunswick

Canada prides itself on multiculturalism, diversity, and equitable education outcomes. Given that education is implemented at a provincial and territorial level, specific policies and practices vary. This is highly relevant given Canada's diversity: almost 20% of the population is foreign-born (2019), 22% is francophone,¹³³ and almost 6% is Indigenous (2018).¹³⁴ While Canada does well in terms of immigrant student educational performance, according to international measures, there are significant concerns about educational equity for First Nations students.^{135,136} Other Canadian research has emphasized the fact that new innovations and practices are necessary to support 21st century learning principles and meet the needs of diverse and special-needs students.¹³⁷

¹²⁹ Ivus, M., Quan, T., Snider, N., "Class, take out your tablets: The impact of technology on learning and teaching in Canada," (January 2020). Information and Communications Technology Council: https://www.ictc-ctic.ca/wp-content/uploads/2020/04/ictc_impact-of-tech-on-learning-teaching-canada_final_en.pdf

¹³⁰ Raisinighani, L., "Teachers' perspectives on culturally diverse classrooms and responsive science and mathematics teaching," 2018: <https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0372169>

¹³¹ Diversity in Public Education: Acknowledging Immigrant Parent Knowledge," Yan Guo University of Calgary, CANADIAN JOURNAL OF EDUCATION 35, 2 (2012)

¹³² Briscoe, P. and Pollock K., "Principals Perceptions of Difference and Diversity in their Student Populations," CAP Journal, 2017: <https://www.edu.uwo.ca/faculty-profiles/docs/other/pollock/cap2017briscoepollock.pdf>

¹³³ Corbeil J., "French and the francophonie in Canada – Language, 2011 Census of Population," Statistics Canada: Census in Brief, 2018: https://www12.statcan.gc.ca/census-recensement/2011/as-sa/98-314-x/98-314-x2011003_1-eng.cfm

¹³⁴ Campbell, C., "Educational equity in Canada: the case of Ontario's strategies and actions to advance excellence and equity for students," School Leadership & Management, 2020: <https://www.tandfonline.com/doi/pdf/10.1080/13632434.2019.1709165?needAccess=true>

¹³⁵ Ibid.

¹³⁶ The source document for this quote uses the term "First Nations" as opposed to "Indigenous" (an encompassing term for First Nations, Métis, and Inuit populations), thus the original research findings are likely specific to First Nations.

¹³⁷ "Leveraging Knowledge for 21st Century Teaching and Learning: Insights and opportunities for knowledge mobilization and future research."

An example of cultural diversity and understanding was provided by an interviewee who shared an experience when teaching a group of students from Mainland China who weren't contributing to online discussion forums. Later the interviewee learned (from a visiting Chinese scholar) that the students were more familiar with providing a collective response, rather than personal responses. Furthermore, they may have been concerned that their contributions could be interpreted as indirect criticism of the instructor. After learning about these cultural differences, the instructor was able to address this issue by asking the students to post a collective response, with preapproval before posting to the group forum. This assurance and encouragement helped students fully participate in the class by providing input. It was noted that *"the important element here is that I had to adapt my digital teaching style to accommodate this cultural difference."*

Another interviewee mentioned that their school administration employed a dedicated learning specialist who focuses on diversity and culture to help immigrants to Canada with education and learning. This position also helped dedicate resources to fund special language software for educators to translate curricula to the student's native language.

Video conferencing was also highlighted as an effective technology for connecting (primarily) non-Indigenous students with Indigenous culture. Indigenous dance, cultural traditions, and discussions with community elders were mentioned as examples of how students from small rural communities were able to learn more in an authentic and personalized manner.

While technology can greatly improve systemic inequalities, educators need to ensure that the adoption of new tools and techniques does not exacerbate current challenges of uneven access and opportunity.

Economic Diversity

The complex issue of Canada's economic divide is increasingly becoming a part of the diversity conversation. Access to technology often correlates with household income, which leads to difficult decisions at the school and district level, such as whether to outfit classrooms with personal devices and other learning technology or place that expense on families. Many educators noted that the rapid advances of technology are resulting in significant financial pressures to keep up with technology procurement. While "Bring Your Own Device (BYOD)" and "one-to-one" device strategies have different advantages and disadvantages, both methods still present significant financial implications.

Some educators noted that uneven access (whether at a district level or student level) risked worsening inequalities, rather than providing remedies. In addition to the risk of burdening families with financial hardship (or stigmatizing students who can't afford high-end equipment), there are also concerns about the presumption that all students have reliable highspeed internet. Previous ICTC research highlighted that access to reliable broadband internet is increasingly necessary for full educational participation for both students and educators alike. Some respondents noted that insufficient broadband access is not just an issue for the smallest, most remote communities of Canada, but also for larger metropolitan areas. An educator from an urban centre in Alberta comments:

 *We recognize that what's happened in the last four or five months [during the pandemic] is that we've really doubled down on the equity problems inside of our culture. So those people who didn't have access to a computer, or access to clear internet, or who don't have the educational literacy skills to support their kids in their house, really have suffered in the last four months.* 

– Educational Technology Specialist, Alberta

Internet connectivity, as the quote suggests, risks reinforcing the inequalities and social challenges that already exist between wealthier and more impoverished areas and those from urban and rural areas.

The pandemic has exacerbated these challenges. While previously, some students who lacked internet at home were able to make use of equipment and access at schools or libraries, these venues were closed for public health reasons. Shared PC's at home among siblings and their working parents, using limited broadband speeds, were cited several times as critical issues for low-income economic regions. These issues also impact an educator's ability to obtain the required technology, maintain connection speeds that allow for adequate classroom management online, along with the necessary opportunities for training and skill development.

Furthermore, uneven socioeconomic realities have been aggravated by the pandemic: working from home (that is, working at all during a health lockdown), is more common for fulltime employees (62%) compared to part-time workers (43%) or hourly worker (40%).

Additionally, those with higher levels of education such as university degrees (83%) were much more likely to work from home than those with high school education or less (35%).¹³⁸ Working from home allows parents with job security and flexible working arrangements to be more accessible and active for assisting their children with online and independent learning. Parents with greater economic resources can also supplement online learning with personalized teaching or tutoring as students are forced toward independent learning. Unsurprisingly, this has exacerbated the gender gap. Women are disproportionately affected by the COVID-19 pandemic, whether through higher job losses or increased responsibility for childcare during the pandemic.¹³⁹ Women typically took responsibility for significantly more childcare duties than men during the lockdown and that “one in three women with school-aged children said their mental health suffered as a result of homeschooling, compared with 20% of men.”¹⁴⁰

Challenges for Educators

Inclusivity issues in education rightfully centre around student and family experiences; however, economic challenges and issues related to broadband access can also negatively impact Canadian educators. Growing costs of technology coupled with utility fees may be difficult for some to manage. While several provinces and territories have detailed emergency policies that help mitigate quick transitions from in-class to virtual learning,¹⁴¹ they still place acute pressure on educators to ensure they are equipped with reliable broadband.¹⁴² As one educator highlighted, “The biggest issue for us financially is that we’re not reimbursed for costs related to internet or hydro, but require strong and expensive internet connections ... for resources; new lesson materials and a good camera weren’t covered, although a 24” monitor and my work laptop were.” This issue extends beyond utilities and equipment to professional development costs. When educators are expected to shift quickly between in-class learning and virtual environments, classroom management and student engagement become challenges. Respondents indicated that resources for both equipment and skills development remain scattered, difficult to access, or poorly coordinated.

¹³⁸ Parr, R., “Coronavirus Highlights Stark Divides Between Those Who Can Work From Home And Those Who Can’t,” *WBUR*, April 10, 2020: <https://www.wbur.org/bostonmix/2020/04/10/coronavirus-working-from-home-economic-divides-income-disparity>

¹³⁹ “Women Disproportionately Affected During Pandemic, U of A Professor Finds,” *University of Arkansas*, June 25, 2020: <https://news.uark.edu/articles/54175/women-disproportionately-affected-during-pandemic-u-of-a-professor-finds>

¹⁴⁰ Adams, R., “Women took on bulk of childcare during British lockdown, study finds,” *The Guardian*, July 22, 2020: <https://www.theguardian.com/education/2020/jul/22/women-took-on-bulk-of-childcare-during-british-lockdown-study-finds>

¹⁴¹ “Tracking Canada’s Education System’s Response to COVID-19,” *People for Education*, Jan., 2021: <https://peopleforeducation.ca/our-work/tracking-canadas-education-systems-response-to-covid-19/>

¹⁴² “Ibid.”



We've received little-to-no training about connecting with our students in synchronous environments. All that was issued at the beginning of the academic year [2020/21] was a letter explaining how to follow the government's strategy. Our board gave us monitors to plug into, after that it was basically 'figure it out and call IT if you have additional questions.' It was challenging having such mixed advice. ▀▀

– Educator Ontario

As students participate in distance learning, the ability to foster learner autonomy (self-led and self-directed learning)¹⁴³ is critical. This autonomy requires educators to have digital skills not typically provided in their formal academic training.¹⁴⁴ The need to leverage technology and support new pedagogical practices for educators runs parallel with issues of student success and inclusivity. Accordingly, while student education and engagement are important considerations for policy discussions surrounding the ongoing use of technology, educator support and training are equally vital.

¹⁴³ Reinders, H., & Balcikanli, C. (2011). Learning to foster autonomy: The role of teacher education materials Studies in Self-Access Learning Journal, 2 (1), 15-25.

¹⁴⁴ "Education and COVID-19: Challenges and Opportunities," UNESCO, Accessed Jan 2021: <https://en.ccunesco.ca/idealab/education-and-covid-19-challenges-and-opportunities>



Conclusion

The current and potential impact of technology on the K-12 education system is a complex issue. A specific exploration into distance learning technologies and their impact on educators, students and their families is encouraged to better understand this educational shift.

For students, an increasingly unpredictable future (including environmental, social, political, and economic challenges) will require both broad competencies and literacies as well as a mixture of technical and digital skills to keep pace with a rapidly changing world. Beyond the K-12 classroom, students will need to embrace life-long continual education and development, as these same tools change rapidly. This ties into many attributes or competencies associated with “21st century learning,” such as **adaptability, passion, creativity, problem solving, and critical thinking.**

This project highlights some best practices and successful examples of technology adoption to advance the edtech discussion. Students will need high digital literacy levels to be successful in the future. Educators will also need stronger digital literacy, updated pedagogical methodologies, continued professional development and support to take advantage of technology developments. Mentorship, collaboration, and the dissemination of first-hand experiences and best practices will play an important role in the evolution of technology in education. The crucial role of the educator, of course, remains uncontested. Technology is best understood as a tool to assist academic efforts. But increasingly the tools and the curriculum are intertwined, which demands new competencies now and in the future.

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 20 key informant interviews (KIIs) with Canadian educators, education subject matter experts, members of educational administration, educational consultants and private industry from across the country.

KIIs played an important role in gathering insights on trends, specifically as they related to educator and student skills and competencies. Candidates were selected based on their location (urban and rural areas, francophone, 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 semi-structured interview questions were designed to identify the candidates pre-existing relationship to education, educational technology, curriculum and policy, independent views toward technology trends and lived experience.

During these KIIs, respondents were also asked to identify the top human (soft) and technical skills for K-12 education. These results were aggregated from the 20 interviews to show relative rankings or common themes based on the frequency in which they were mentioned.

Secondary Research:

The secondary research for this study focused on an analysis of existing 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 are inherent limitations to this research in terms of sample size and the qualitative nature of the interviews.

ICTC conducted 20 KIs, which is a modest sample pool of interviewees. This means that these responses must be regarded as insights and cannot necessarily be taken as objective “trends” that represent the Canadian experience.

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.