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Navigating the digital world: development of an evidence-based digital literacy program and assessment tool for youth

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Abstract

The rapid expansion of digital connectivity has provided youth with wide-ranging access to digital platforms for communication, entertainment, and education. In light of this profound shift, there have been growing concerns about online safety, data privacy, and cybersecurity. A critical factor influencing the ability of youth to responsibly navigate digital platforms is digital literacy. While digital literacy programs have been implemented in various regions worldwide, significant disparities remain not only in overall digital literacy levels, but also the assessment of digital literacy initiatives. To address these challenges, an environmental scan and literature review were conducted to identify existing digital literacy programs in Canada developed specifically for youth, as well as digital literacy assessment tools, respectively. The search encompassed peer-reviewed articles, organizational curricula, and assessment measures indexed in various databases and organization websites. The environmental scan identified 15 programs targeting key components of digital literacy such as data safety, cyberbullying, and digital media. The literature review identified 12 digital literacy assessment tools. Based on the findings, data were synthesized from shortlisted programs and assessment tools to inform the development of both a new digital literacy program and assessment tool to complement the youth-focused program. The new program focuses on four key components: (1) digital fluency, (2) digital privacy and safety, (3) ethics and empathy, and (4) consumer awareness. A 15-item assessment tool was also developed consisting of 4–5 questions specific to each program component. Given the growing importance of digital competencies, a youth-focused program and assessment tool are crucial for understanding and addressing digital literacy among this vulnerable cohort. This program's adaptability allows for customization across sociodemographic target groups, including culturally diverse and geographically remote communities—an aspect that has the potential to enhance digital literacy across settings. Implementing digital literacy programs can better prepare youth for an increasingly digital world, while minimizing potential risks associated with technology use.

Keywords: Digital literacy, Youth, Digital literacy assessment, Digital literacy program, Data privacy, Data safety

Introduction

Digital connectivity has rapidly evolved in the past decade (Burr et al., 2020; Korte, 2020), and contributed to fundamental shifts in how people engage with each other, find information, and access services (Bach et al., 2018). Of all the demographic groups, youth have increasingly turned to technology and the internet as preferred tools for communication, socialization, entertainment, and more recently, education (Bach et al., 2018; Pandya & Lodha, 2021). From the use of social media applications to online gaming and educational resources, digital technology has become an integral part of the daily routines of many youth globally (Pérez-Escoda et al., 2020; *The Lancet Child and Adolescent Health*, 2018).

Nevertheless, there are variations in digital platform use, and more importantly, digital literacy levels among youth within and across countries (Bandura & Leal, 2022; Human Rights Council, 2023). In Canada, these disparities are particularly pronounced, with a national 'digital divide' resulting from stark cross-country differences in both digital access and digital literacy levels (Aydin, 2021; Hadziristic, 2017). While it is true that 80–96% of Canadian youth aged 13–24 years own or have access to smartphones (Rideout et al., 2022; Secretariat & Secretariat, n.d.; Vernon et al., 2018), certain factors such as gender, education, and geographic location have a significant influence on the digital skills of Canadian youth (Hadziristic, 2017), with some subgroups still demonstrating significantly lower digital literacy skills than their peers, including Indigenous youth, newcomers to Canada, youth living in poverty or in northern, rural, and remote communities (Government of Canada, 2023).

Despite these disparities in connectivity, digital technology use by youth is growing globally (Graafland, 2018; Haddock et al., 2022; *The Lancet Child and Adolescent Health*, 2018). In addition to recreational use (Joshi et al., 2019), online learning has become increasingly common in countries such as Canada, particularly due to the Coronavirus disease pandemic which led to widespread school closures and adoption of remote learning among all levels of schooling in both urban (Quintana et al., 2020) and rural jurisdictions (Kannan et al., 2022). Many jurisdictions have opted to continue offering some level of online learning in the post-pandemic era (LaBonte et al., 2021). The National Center for Education Statistics reports that in the 2021–2022 school year, 33% of schools continued to offer remote learning, and 10% offered hybrid models of instruction (National Center for Educational Statistics, 2022) that combined in-person and online learning (LaBonte et al., 2021). While increased digital access improved quality of life for many, it has also magnified concerns about online safety, data privacy, and cybersecurity (Government of Canada, 2016). Misinformation, identity theft, and cyberbullying are among the numerous digital concerns which are particularly important among vulnerable groups such as youth (Human Rights Council, 2023).

Research has shown that despite being early adopters of evolving technology (Haddock et al., 2022), youth often demonstrate limited critical thinking skills and low media literacy, which can lead them to share information impulsively (Machete & Turpin, 2020; Pérez-Escoda et al., 2020) and therefore make them vulnerable to online misinformation (Nan et al., 2022). Privacy is another growing concern (Lupton, 2021), as personal information can be collected, stored, and shared online often without their consent or knowledge (Donelle et al., 2021), rendering youth vulnerable to identity theft, online fraud, and

other forms of online exploitation (Quayyum et al., 2021). Studies suggest that youth are often unaware of who has access to their posted content and the permanence of their digital footprint. Such oversight can not only impact their quality of life, but also lead to the exploitation of their personal information (Donelle et al., 2021; van der Velden & El Emam, 2013).

The ability to navigate the benefits and risks of digital connectivity largely hinges on one key factor—digital literacy. Digital literacy is “the ability to access, manage, understand, integrate, communicate, evaluate, and create information safely and appropriately through digital technologies” (Law et al., 2018) and includes individuals’ ability to use various digital devices and software (British Columbia Ministry of Education and Child Care, 2022). Digital literacy has become a crucial skill for young people to navigate and succeed in the increasingly technology-driven world, with these skills becoming increasingly relevant in all environments, including school, recreation, home, and work (Government of Canada, 2023). Research shows a concerning trend of low digital literacy among youth, particularly in areas with limited digital connectivity (i.e., remote areas) (Bhawra et al., 2022; Schreurs et al., 2017). This warrants the need for dedicated digital literacy programs, both to aid learning and decision-making, as well as to mitigate some of the prominent concerns associated with increased technology usage (Pérez-Escoda et al., 2020). Several jurisdictions in Canada, particularly in urban centres or private school boards, have begun implementing specific digital literacy curricula (British Columbia Ministry of Education and Child Care, 2022; Government of Ontario, 2022; Nova Scotia Ministry of Education and Early Childhood Development, 2022); however, adoption of digital literacy programs is not mandatory across all school boards.

Given the importance of digital literacy, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) led the development of a Digital Literacy Global Framework which emphasized the role of digital literacy in achieving Sustainable Development Goal (SDG) 4—Quality Education—which includes a specific indicator (4.4.2) to measure the percentage of youth and adults who have achieved at least a minimum level of proficiency in digital literacy skills (Law et al., 2018). UNESCO’s framework is informed by global evidence on the core components of digital literacy and associated evaluation criteria, which can serve as a foundation for the development of digital literacy curricula across jurisdictions (Law et al., 2018). The UNESCO framework and persistent digital divide in countries such as Canada underscores the pressing need for comprehensive digital literacy programs to address these disparities and empower youth in the digital age.

Thus, this study aimed to develop a tailored digital literacy program for youth in Canada, as well as a robust digital literacy assessment tool designed to evaluate the impact of the newly developed program by measuring digital literacy before and after program implementation. To inform the development of the program and assessment tool, an environmental scan and literature review were conducted to explore the current landscape of digital literacy programs and assessment tools for youth in Canada. This work was guided by the following research questions: (1) Based on an environmental scan of peer-reviewed and grey literature, what digital literacy programs or frameworks have been developed for youth in Canada? Specifically, (i) What are the core topic areas (e.g., data safety, cyberbullying) of digital literacy programs/frameworks? and (ii) Who is the

target audience for existing digital literacy programs/frameworks?; (2) Based on a literature review of peer-reviewed articles, what assessment tools and/or questionnaires have been used to evaluate digital literacy levels? Specifically, (i) What digital literacy assessment tools have been tailored for youth?

Methods

Environmental scan

An environmental scan was conducted to explore the current landscape of digital literacy programs for youth in Canada. This method allowed for the exploration of digital literacy programs in peer-reviewed publications as well as grey literature (Charlton et al., 2019; Shahid & Turin, 2018). The environmental scan aimed to identify both peer-reviewed journal articles of existing programs, as well as organizational reports or school curricula describing programs or frameworks in Canada which aimed to improve digital literacy among youth. The environmental scan was conducted by searching for programs and frameworks in relevant databases (Aromataris & Riitano, 2014) including the Education Resources Information Center (ERIC) database which focuses on education research, as well as Google and Google Scholar to capture programs or curricula that may not be published in peer-reviewed literature (i.e., from organizational websites). Moreover, in order to hone in on previously developed curricula (Shahid & Turin, 2018), specific organizational and school board websites within Canada were also searched. Search terms used in the environmental scan included a combination of “Digital Literacy”, “Program”, “Framework”, “Program development”, “Youth”, and “Canada.” The key inclusion criteria for this scan included identification of programs which: discussed an educational program or curriculum related to digital literacy; were developed for children, youth, or adolescents; were developed or published in the last 6 years (2018–2023); were designed for implementation either in person or online; and were available in English. Exclusion criteria were documents: not published in English, not targeting youth or adolescent populations, or not clearly describing digital literacy as a focus area for a given program or curriculum.

Database search for peer-reviewed literature

A peer-reviewed literature review for existing digital literacy assessment tools was conducted to determine how awareness and knowledge uptake from digital literacy programs were being assessed (Ahmed et al., 2016). The literature search aimed to identify digital literacy assessment measures that could be used to assess digital literacy status among youth (i.e., a reference point to identify changes in digital literacy pre/post program or intervention participation). Peer-reviewed articles indexed in ERIC, MEDLINE, and Google Scholar were explored (Aromataris & Riitano, 2014), as these databases encompass articles across the domains of education research, life sciences, and other academic literature, respectively. This search strategy enabled a comprehensive review of digital literacy assessments tools that may have been developed or used across disciplines. Search terms used included a combination of “Digital Literacy”, “Digital quotient”, “Digital citizenship”, “Measurement”, “Assessment”, and “Youth”. Relevant literature cited within articles were also reviewed and shortlisted if they discussed an assessment tool related to digital literacy and met general inclusion criteria (i.e., were developed or

modified for children, youth, or adolescents; were designed for implementation online; and available in English).

Data extraction and synthesis

Following best practices for data extraction and synthesis of literature (Cooper & Hedges, 2009; Paré & Kitsiou, 2017), titles and abstracts of articles identified through the environmental scan (describing digital literacy programs) and peer-reviewed literature search (for digital literacy assessment tools) were screened for relevance based on the core inclusion and exclusion criteria. For articles identified within ERIC and MEDLINE databases, potentially relevant articles were downloaded to the referencing software, Mendeley, where duplicate records were removed. Similarly, titles and abstracts were screened in Google and Google Scholar, however given the large number of hits generated by the search engines, only potentially relevant articles, reports, and curricula documents were downloaded to Mendeley for review based on screening of titles, abstracts, and/or executive summaries against our inclusion criteria. One author screened the identified records (MCB) and removed irrelevant literature according to the inclusion and exclusion criteria. A second reviewer (JB) validated included records for content, scope, and relevance (Waffenschmidt et al., 2019). A data abstraction form was designed in Excel, and two researchers (MCB, JB) extracted the data of included records (Cooper & Hedges, 2009; Paré & Kitsiou, 2017; Waffenschmidt et al., 2019). Discrepancies were resolved through discussion among the researchers.

Eligible data from all identified digital literacy programs and assessment tools meeting the inclusion criteria were synthesized (Cooper & Hedges, 2009; Paré & Kitsiou, 2017) and are presented in Table 1. Data on the general characteristics of the included studies included program name, a brief description of the organization and/or program, key program components, and program location. Data from all identified assessment tools for digital literacy are summarized in Table 2. Summary data of the assessment tools included year of publication, location where the tool was developed, age of target population, the goal of the assessment, key indicators assessed, whether the assessment is skills based or questionnaire based, and length of the assessment (Paré & Kitsiou, 2017; Petticrew & Roberts, 2006).

Digital literacy program and assessment tool development

Findings from the environmental scan were synthesized and analyzed (by MCB, JB, TRK) to create a new digital literacy program tailored for youth (Petticrew & Roberts, 2006). Key themes and topic areas identified through the environmental scan were shortlisted to inform the development of a new program. Topic areas that were considered core digital literacy components in peer-reviewed literature, theoretical frameworks such as the UNESCO Digital Literacy Global Framework (Law et al., 2018), or those described in the majority of shortlisted programs were included in the newly developed program. Topic areas were grouped by theme and consolidated to create the final list of program components. Specific learning objectives were developed for each component, taking into consideration our target population (i.e., youth) (Chatterjee & Corral, 2017). The newly developed digital literacy program is evidence-based with topic areas and components selected from seminal work in digital literacy and digital literacy education (British

Columbia Ministry of Education and Child Care, 2022; Law et al., 2018). The program was designed to capture a breadth of information across each of the seven competencies described in the Digital Literacy Global Framework (i.e., fundamentals of hardware and software; information and data literacy; communication and collaboration; digital content creation; safety; problem solving; and career-related competences) (Law et al., 2018). As the primary audience for this curriculum is youth in Canada, content was sourced from Canadian sources (e.g., Office of the Privacy Commissioner of Canada) where possible (Office of the Privacy Commissioner of Canada, 2018).

Given that the purpose of the digital literacy assessment tool was to evaluate the pre/post change in digital literacy following implementation of the newly developed program, a new tool was developed (by MCB, JB, TRK) to assess various components of digital literacy identified in the program (Kishore et al., 2021). In our research process, we sought to ensure the accuracy and relevance of our digital literacy assessment by consulting previously validated measures of digital literacy (Lazonder et al., 2020; Perdana et al., 2019; Saxena et al., 2018). These established measures served as valuable guides in the formulation of questions tailored to address the key topics covered in our digital literacy program (Kishore et al., 2021). To accurately gauge the impact of our program on participants' digital literacy levels, we adopted a comprehensive approach, developing at least one question within our assessment tool for each subtopic and skill area included in our program (Kishore et al., 2021). This assessment tool will therefore enable evaluation of the effectiveness of our program and enable specific areas of program improvement.

Results

Summary of digital literacy programs

A total of 13 relevant digital literacy frameworks, programs, and organizations were identified through the environmental scan (Table 1). We classified the identified frameworks, programs, and organizations into 6 broad categories: (A) school-based digital literacy and coding courses ($n=3$), which included formal coding, engineering design, and applied design and technologies courses and/or curricula that are integrated into the mathematics and science curricula; (B) school-based digital literacy workshops ($n=5$), where programming for students is provided in the school setting by third party organizations; (C) teacher education/training models ($n=4$), where teachers receive formal training and subsequently serve as facilitators or digital literacy lessons are co-taught with digitally-savvy teachers; (D) structured lesson plans and educational resources ($n=8$), where parents and teachers are provided lesson plans or outlines, differentiation strategies, and implementation tips that can be used to educate youth about digital literacy concepts; (E) full-time bootcamp programs ($n=3$), where individuals of any age can participate in intensive and accelerated learning programs at varying skill levels; and (F) part-time extracurricular programs ($n=4$), where individuals of any age can participate in before/after school and weekend programs, camps during school breaks, or drop-in programming. Programs may fall under more than one category depending on the types of programming offered by each organization. Among the 13 identified programs, 8 were Canada-wide, 2 were developed and delivered in Ontario, and 1 in each Manitoba, British Columbia, and Nova Scotia.

Table 1 Youth-focused digital literacy programs and frameworks

Program and/or organization name	Type of program	Description	Key components	Location
<i>Formal education system</i>				
BC Ministry of Education and Child Care: Digital Literacy Framework (British Columbia Ministry of Education and Child Care, 2022)	School-based digital literacy and coding courses Structured lesson plans and educational resources	A digital literacy framework to help educators integrate technology and digital literacy-related activities into their classroom practice The framework provides some basis for the development of assessment tools for the digital literacy competencies	Research and information literacy Critical thinking, problem solving, and decision making Creativity and innovation Digital citizenship Communication and collaboration Technology operations and concepts	British Columbia, Canada
Nova Scotia Ministry of Education and Early Childhood Development: Technology Education (Nova Scotia Ministry of Education and Early Childhood Development, 2022)	School-based digital literacy and coding courses	The Nova Scotia government has developed a Technology education course to provide students hands-on design problem-solving skills The course is designed to teach students to use a range of technological tools, processes, and applications; integrate technology education with other academic disciplines; design and create devices and objects that solve technological problems; and explain the consequences of technology and how it affects society	Exploring technology Communications technology Design Production technology Communications technology Computer programming	Nova Scotia, Canada
Government of Ontario: STEM Skills and Connections (Government of Ontario, 2022)	School-based digital literacy and coding courses	The Ontario government introduced a new science and technology curriculum and de-streaming the Grade 9 science course The new STEM programming includes mandatory learning on coding, data literacy, mathematical modeling, and an emphasis on financial literacy	Coding Engineering design process Algorithms Data input, storage, processing, and output Project management and program design Controlling large systems in action Robotics	Ontario, Canada

Table 1 (continued)

Program and/or organization name	Type of program	Description	Key components	Location
<i>Informal education system</i>				
Toronto Public Library (Toronto Public Library, 2022)	Part-time extracurricular programs	The Toronto Public Library provides free programs and classes as well as access to computers and equipment for all age groups. Programming includes technology talks, hands-on coding workshops and other classes for a wide range of interests.	3d printing 3d design Audio recording and editing Coding Image editing (e.g., adobe photoshop) Robotics Sewing (at fabrication studio) Video recording and editing	Ontario, Canada
CoderDojo program (Kelly et al., 2023)	Part-time extracurricular programs	Coding clubs for children and youth to stimulate digital capacity and adoption among rural young people administered by three branches of the Western Manitoba Regional Library. The CoderDojo program incorporates a 'belt' system corresponding to beginner, intermediate, and advanced 'Scratch' skills.	Scratch Raspberry Pi Pico Python Unity Web (HTML, CSS, animations)	Manitoba, Canada
Let's Talk Science (Let's Talk Science, 2022)	School-based digital literacy workshops Teacher education/training models Structured lesson plans and educational resources	Programs and resources for educators to improve youth education and engagement in STEM. Programming is available at no cost to schools, early education centres, community organizations, and parents/caregivers. Programming includes Career profiles in STEM, hands-on activities exploring STEM concepts, lesson plans for educators, interactive resources (activities, eBooks, videos), national STEM projects using real-world data.	Cybersecurity Coding Artificial intelligence Robotics Data privacy	Canada
Kids Code Jeunesse (Kids Code Jeunesse, 2022)	School-based digital literacy workshops Teacher education/training models Structured lesson plans and educational resources	Programs that provide access to digital skills education, with a focus on girls and underserved communities. Programming includes online training for educators, code in the classroom workshops for educators and students, code clubs for youth, online resources for parents and youth.	Artificial intelligence JavaScript Scratch Micro:bit Python	Canada

Table 1 (continued)

Program and/or organization name	Type of program	Description	Key components	Location
Canada Learning Code (CLC) (Canada Learning Code, 2022)	School-based digital literacy workshops Teacher education/training models Structured lesson plans and educational resources	Programs that provide digital literacy education and working to equip people living in Canada with technical skills 1-day and multi-day workshops for students 7-week program for adults March Break and Summer Camps Code Mobile, a traveling computer lab on wheels	Basic digital skills Coding Robotics HTML/CSS JavaScript Ruby on rails Python Graphic design Introductions to artificial intelligence Introductions to blockchain	Canada
Pinnguaq (Pinnguaq, 2019)	School-based digital literacy workshops Teacher education/training models Structured lesson plans and educational resources Full-time bootcamp programs	Programs designed to support the development of STEAM skills through innovative technology, art, and play Programming includes Free in-person and remote digital skills workshops, camps, and online programs for learners of all ages	App development Art and design Computational thinking Computer fundamentals Digital storytelling Engineering Game design Online safety Root and stem Sound design Video production	Canada
Boys and Girls Clubs of Canada: Kid Tech Nation (Boys and Girls Club, 2022)	Full-time bootcamp programs Part-time extracurricular programs	Program teaching youth digital skills in a fun, beginner-friendly, and collaborative environment The program focuses on engaging young people that are typically underrepresented in STEM fields (i.e., girls, racialized and Indigenous children, and children from newcomer families) Programming includes youth mentorship, digital literacy skill development, and coding	Digital skills Coding concepts Internet safety Computational thinking	Canada

Table 1 (continued)

Program and/or organization name	Type of program	Description	Key components	Location
Actua: STEM programming (Actua, 2022)	Structured lesson plans and educational resources Full-time bootcamp programs Part-time extracurricular programs	A network of 35 university and college members that deliver coding and digital skills programming Programming includes school workshops, summer camps, after-school programs, year-round clubs, and community outreach initiatives for youth in Grades K–12 in every Canadian province and territory	App creation Robotics Artificial intelligence Big data	Canada
Media Smarts: A Day in the Life of the Jos (Maqsood & Chiasson, 2021)	Structured lesson plans and educational resources	A classroom-based cybersecurity, privacy, and digital literacy game for elementary school students	Cyberbullying Data privacy Online reputation Privacy and ethics Verifying the veracity of information online	Canada
<i>Online learning</i> Media Smarts: Use, Understand, Create (Media Smarts, 2022)	School-based digital literacy workshops Structured lesson plans and educational resources	A framework developed for teaching digital media literacy in Canadian schools Provides teachers with supporting lessons and interactive resources that are linked to curriculum outcomes for every province and territory	Ethics and empathy Privacy and security Community engagement Digital health Consumer awareness Finding and verifying Making and remixing	Canada

This table summarizes youth-focused digital literacy programs and frameworks across Canada. Programs noted under 'formal education system' refers to those offered in school settings, 'informal education system' refers to other organizational setting such as community centers or non-profit organizations, and online learning refers to programs administered and accessed electronically (i.e., via digital devices such as computers and smartphones)

Table 2 Digital literacy program overview

Component	Learning objectives	Subcomponents
Digital fluency	<p>Ability to search in a systematic way for information specified in a web search query</p> <p>Ability to recognize and authenticate sources and information online</p> <p>Understand what apps are and how they can be used to achieve/complete goals and tasks</p> <p>Understand the difference between hardware and software and how they work together</p> <p>Understand what is considered data and where to appropriately store data</p>	<p>Searching and processing</p> <p>Authenticating information</p> <p>Apps</p> <p>Computing</p> <p>Data</p> <p>Data backups</p> <p>Data storage</p>
Digital security and privacy	<p>Understands the concept of privacy in their everyday lives, and as it relates to using the Internet</p> <p>Awareness that many websites ask for information that is private and has the ability to responsibly handle such requests</p> <p>Knowledge how to identify secure sites by looking for privacy policies</p> <p>Knowledge of how and where to appropriately back up information</p> <p>Understands the reasons why people use passwords, the benefits of using passwords, and knows strategies for creating and keeping strong, secure passwords</p> <p>Understands data collection techniques</p> <p>Knowledge of digital worms/viruses and strategies to avoid them</p> <p>Knows strategies for guarding against identity theft and scams that try to access his/her private information online</p>	<p>Data sovereignty</p> <p>Data sharing</p> <p>Cookies</p> <p>Privacy and security</p> <p>Passwords</p> <p>Digital viruses</p> <p>Identity theft</p> <p>Data collection</p>
Ethics and empathy	<p>Understands the concepts of ethical behaviour and online ethics</p> <p>Understands their responsibility to protect the privacy of themselves and others when sharing information online, and how it relates to data sovereignty</p> <p>Understands that the information they put online leaves a digital footprint</p> <p>Understands what cyberbullying means and what they can do when they encounter it</p> <p>Understands the concept of having ownership over creative work and respecting the creative work of others</p> <p>Understands the importance of citing all sources when they do research</p> <p>Understands the concept of plagiarism, and when and how it is okay to use the work of others</p>	<p>Digital identity</p> <p>Digital awareness</p> <p>Copyright and plagiarism</p> <p>Harassment and cyberbullying</p>
Consumer awareness	<p>Knowledge of online spam, the forms it can take, and how to identify strategies for dealing with it</p> <p>Reading and understanding the implications of website Terms of Service and privacy policies</p> <p>Understands that the purpose of product websites is to encourage buying the product and is aware of methods used to promote products on these sites</p> <p>Understands the ways websites and companies collect data online and utilize it to personalize content for their users, as well as consider companies' motives in doing so</p>	<p>Phishing</p> <p>Terms of service</p> <p>Digital advertising</p>

A summary of key program components is presented in Table 1. Substantial overlap was found in the topics addressed across identified programs. Topics included: introduction to computers, ethics and empathy, cybersecurity, data privacy, data literacy, community engagement, digital health, consumer awareness, digital media and arts, and

artificial intelligence (AI). Our team thoroughly reviewed key components of previously developed programs and determined which elements were relevant for the development of the current digital literacy program for youth.

Development of a tailored digital literacy program

Key program components were identified through the environmental scan. Four key topic areas were selected given the number of times they were mentioned in other programs and their importance to overall digital literacy for youth. The four key program components include: (1) digital fluency, (2) digital privacy and safety, (3) ethics and empathy, and (4) consumer awareness. Each component addresses several relevant subcomponents. The learning objectives for this program were adapted from the Digital Literacy Framework for Grades 10–12 developed by the Ministry of Education and Child Care of British Columbia (British Columbia Ministry of Education and Child Care, 2022). An overview of each program component's learning objectives and subcomponents is presented in Table 2.

The digital fluency component aims to provide youth with the skills needed to search and authenticate information online, understand and operate applications, and the basics of computers, data, and data storage. The digital privacy and safety component of this program educates youth about the concept of privacy in their everyday lives and how it relates to using the Internet, the importance of passwords, digital viruses, and

In-class activity #5:

Discussion with students:

What does data sovereignty mean to you?

Why is data sovereignty important?

How do you think data sovereignty is connected to our self-governance? *

*For older students grade 7 and above the discussion can be expanded to discuss self-governance and other more complex topics. For younger students, discussion can be centred around data sovereignty and how it relates to their rights.

For a primarily non-indigenous audience, Animikii Inc. (Animikii, 2019) developed questions to help give context to this concept:

If your parents control your finances and only dole out payments via weekly allowances, do you have real authority over your own affairs?

If your parents are second-guessing everything you do, who's governing your behaviour?

If your parents meddle in your personal business and sow discord in your relationships, are they sticking their noses where they don't belong?

Now replace "your parents" with "the Government of Canada" and "you" with "Indigenous Peoples".

If the Government of Canada controls Indigenous Peoples' finances and only doles out payments via allowances, do Indigenous Peoples have real authority over their own affairs?

If the Government of Canada is second guessing everything Indigenous Peoples do, who's governing their behaviour?

If the Government of Canada meddles in Indigenous Peoples' personal business and sows discord in Indigenous Peoples' relationships, is the Federal Government sticking its nose where it doesn't belong?

Fig. 1 Example of modifiable in-class activities included in the program

identity theft. The ethics and empathy component of the program educates youth about digital citizenship, including their digital identity, digital awareness, and cyberbullying. The ethics and empathy topic also addresses copyright and plagiarism on the internet. The consumer awareness component aims to ensure that youth understand their rights as consumers and how their information is being tracked and shared.

The program has been developed for both paper-based as well as online delivery. The program has also been developed to adapt to various target audiences and geographic locations across Canada (e.g., urban youth, remote Indigenous communities, etc.). The adaptability of the program is primarily through the use of modifiable in-class activities (Fig. 1). Areas throughout the program where real-world examples would be useful to contextualize the information for learners are highlighted (Animikii, 2019). Preliminary examples are provided in the program; however, educators and program coordinators are encouraged to adapt the examples to fit their context and target audience. The full curriculum can be found in the Additional file 1.

Digital literacy assessment tools

A total of 103 articles in MEDLINE and ERIC were identified after removing duplicates, as well as 10,000+ hits in Google Scholar which were reviewed against the inclusion/exclusion criteria as described in the “Methods” section. A total of 18 results across all databases/search engines met the inclusion criteria. Four of the identified digital literacy assessment tools utilized complex software to assess digital literacy and computer skills. The remaining 15 assessment tools measured digital literacy through the use of self-reported questionnaires. A summary of the relevant digital literacy assessment tools is presented in Table 3. While publication years ranged from 2006 to 2023, most articles reviewed were published between 2018 and 2020. While each tool evaluated its own distinct set of indicators, several indicators were commonly found across assessment tools. These indicators included: searching and processing, evaluating digital information, communication using technology, knowledge and understanding of computers and technology, digital safety, and attitudes towards digital literacy.

Development of a digital literacy assessment tool

Findings from the environmental scan were used to develop a digital literacy assessment tool to assess change in digital literacy following completion of this program (pre vs. post program implementation). Indicators identified among previously validated measures of digital literacy were used to guide the development of questions specific to the key digital literacy topics covered in the program. A 15-item assessment tool consisting 4–5 questions specific to each module in the program was developed. Topics assessed from each module included: (1) Digital fluency: searching and processing, authenticating information, computing, and the cloud; (2) Digital security and privacy: data sharing, passwords, data collection, digital viruses, and identity theft; (3) Ethics and empathy: digital identity, harassment and cyberbullying, copyright, and plagiarizing; (4) Consumer awareness: phishing, terms of service, and digital advertising. In addition to module-specific questions, a brief baseline

Table 3 Digital literacy assessment measures

Measure	Year	Country	Population	Purpose	Indicators	Type of test	Length (items, time)
iSkills Assessment (Katz, 2007)	2007	United States	Young adults	To measure students' ability to navigate, critically evaluate and make sense of the wealth of information available through digital technology	Define Access Evaluate Manage Integrate Create Communicate	Skill-based test	15 tasks, 75 min
ACTS21 Assessment (Griffin et al., 2012)	2012	Australia Finland Singapore USA Costa Rica Netherlands	Adolescents	To evaluate the skills of students in the twenty-first century and to introduce the learning in the curricula	Knowledge Skills Attitudes Values Ethics	Skill-based test	NR, NR
TEL Assessment (US Department of Education, 2018)	2018	United States	Adolescents	To assess technological literacy knowledge and skills that identifies the understandings and applications of technology principles that are important for all students	Technology and society Design and systems Information and communication technology	Skill-based test	NR, 60 min
International Computer and Information Literacy Study (ICILS) Assessment (Fraillon et al., 2019)	2019	United States	Adolescents	To investigate, in a range of countries, the ways in which young people are developing computer and information literacy to support their capacity to participate in the digital age	Understanding computer use Gathering information Producing information Digital communication Attitudes towards information and communication technologies	Skill-based test + Questionnaire	NR, 80 min
Nicholas and Ng (2019)	2019	Australia	Adolescents	To investigate Australian students' perceptions of their ability to use mobile technology for learning and everyday activities	Social emotional Cognitive: Understanding multimodality Cognitive: Assess and apply Technical skills	Questionnaire	26 items, NR
Lazonder et al. (2020)	2020	Netherlands	Children	To assess how children's skills to collect, create, transform, and safely use digital information progressed	Operating browsers and search engines Using keywords and queries Evaluating information Safe and secure use of online information	Questionnaire	16 items, NR

Table 3 (continued)

Measure	Year	Country	Population	Purpose	Indicators	Type of test	Length (items, time)
Saxena et al. (2018)	2018	India	Young adults	To assess the digital literacy and smartphone usage amongst dental students including their perception about smartphone/internet usage for learning purposes	Smartphone/internet usage Assessment of digital literacy Students' attitudes towards implementation of e-technology in the dental curriculum	Questionnaire	NR, NR
Hatlevik et al. (2017)	2017	Norway	Adults (teachers)	To examine the relationship between teacher's self-efficacy, strategic use of information, digital competence, and use of information and communication technologies	Self-efficacy in basic information and communication technologies Self-efficacy in online collaboration Strategies to evaluate information Use of information and communication technologies Digital competence	Questionnaire	26 items, NR
Information and communication technologies (ICT) literacy scale (Hatlevik, 2017)	2017	Norway	Adolescents	To assess the overall measurement invariance and potential differential item functioning of an information and communication technologies literacy measure across gender	Searching and processing Producing Communicating Evaluating digital information	Questionnaire	14 items, NR
Nguyen and Habók (2020)	2020	Vietnam	Young adults	To assess students' digital knowledge and their perceived skills, their attitudes toward the use of digital technologies, and the frequency of use of technology applications in English learning	Searching and evaluating information Creating Communicating Collaborating E-safety	Questionnaire	5 sections, NR
Perdana et al. (2019)	2019	Indonesia	Adolescents	To measure students' digital literacy skills and prove whether there were differences in student skills based on education levels	Knowledge Assembly Content evaluation Internet searching Hyper textual navigation	Questionnaire	10 items, 60 min
Jin et al. (2020)	2020	China	Children and adolescents	The development of an assessment suitable for measuring DL at primary and secondary school levels	Information and data literacy Communication and collaboration Digital content creation Digital safety Problem solving	Questionnaire	80 items, 50 min

Table 3 (continued)

Measure	Year	Country	Population	Purpose	Indicators	Type of test	Length (items, time)
Screenshots program evaluation (Bickham et al., 2021)	2021	United States	Children	To evaluate the Screenshots program in increasing participants' knowledge about key concepts of digital citizenship and in shifting beliefs and intended behaviors to align with prosocial and safe online interactions	Curriculum knowledge Online bullying Online citizenship beliefs Online citizenship behaviour Conflict resolution Responsiveness and relevance	Questionnaire	43 items, 20 min
Youth Digital Citizenship Scale (Kim & Choi, 2018)	2018	Korea	Adults (teachers)	To evaluate digital citizenship among adolescents from their teachers perspective	Self-identity Activity in online Fluency for digital environment Ethics for digital environment	Questionnaire	18 items, NR
Security, privacy, and digital literacy knowledge measure (SPDLK) (Magsood & Chiasson, 2021)	2021	Canada	Children	To assess cybersecurity, privacy, and digital literacy knowledge in the pre- and post-participation in the "A Day in the life of Jos" digital literacy program	Cybersecurity Privacy Digital literacy	Questionnaire	15 items, 15 min
Digital Citizenship Scale (DCS) (Choi et al., 2017)	2017	United States	Adults	To measure abilities, perceptions, and levels of participation of young adults in Internet based community	Internet political activism Technical skills Local/global awareness Critical perspective Networking agency	Questionnaire	26 items, NR
Be Internet Awesome Evaluation (Jones et al., 2023)	2023	United States	Children	To assess the impact of the Be Internet Awesome program for youth (grades 4–6) on knowledge, attitudes, and behaviors related to improved safety online	Technology use Knowledge of online safety concepts Self-efficacy to handle online problems Online privacy behaviors and attitudes Online harassment Help-seeking from adults for online problems Online civility behaviors	Questionnaire	27 items, 30–40 min
Evaluation of Digital Competence for Compulsory Education Students (ECODIES) (Casillas-Martín et al., 2020)	2020	Spain	Adolescents	To assess the level of digital competence through knowledge, abilities, and attitudes among compulsory education students	Information Communication Content creation Safety Problem solving	Questionnaire	108 items, NR

questionnaire was included to gather information regarding youth demographics as well as their internet access and usage, communication, and social networking patterns. The final measure adapted version can be found in the Additional file 1.

Discussion

Digital literacy has become increasingly important to navigate the complexities of a digital world, particularly among youth, and can be considered an essential skill to function in the twenty-first century (Pérez-Escoda et al., 2020; Richardson et al., 2022). This study aimed to create a digital literacy program tailored for youth in Canada, as well as an assessment tool to enable evaluation of digital literacy levels pre- and post-program implementation to identify existing competencies and disparities in digital literacy levels. To date, there is no national program which has been adopted for diverse youth across the country, which creates challenges for measurement and evaluation of digital literacy levels over time. The focus on youth populations was deliberate, because although youth are generally considered to possess a higher digital quotient (Keach, 2014), their dependence on digital platforms for everyday tasks places them at potentially increased risk of misinformation, identity theft, and cyberbullying (Silveira et al., 2022).

While general digital literacy skills programs are a necessary component of national strategies (Medhurst et al., 2023), it is important to recognize that vulnerable subgroups of youth may require targeted digital literacy programs that address key gaps or challenges in order to minimize inequities (Vassilakopoulou & Hustad, 2023). Similar successful initiatives have been implemented in the United States (Drazich et al., 2021), with a strong emphasis on the inclusion of low-income populations, as well as in Indonesia, where digital literacy models have placed a specific focus on women who may be at increased risk of gender bias, specifically in the workplace (Kusumawardani et al., 2022). While access and use of the internet and digital tools by youth in the western world is near universal (Donelle et al., 2021; Secretariat & Secretariat, n.d.; Żerebecki & Oprea, 2022), there are variations of digital literacy across jurisdictions and sociodemographic groups (Bandura & Leal, 2022; Hadziristic, 2017; Human Rights Council, 2023). Acknowledging these variations, and taking a targeted approach to program design, we focused on developing a digital literacy program to address current gaps in Canadian digital literacy curricula.

Our study found a range of programs across Canada dedicated to improving digital literacy among youth. The majority of these programs focused on equipping youth with computer science and data science skills such as coding data analytics, and development of AI in order to foster an understanding of the impact of technology on everyday life. The practical, hands-on experience provided by many of these programs aims to prepare students for careers in science, technology, engineering, and mathematics (STEM). While skills-based programs are critical for youth to navigate an increasingly digital world, a key limitation of many of the existing programs appears to be the prioritization of technical skills over critical concepts related to acceptable online behavior, such as ethics, data ownership, safety, and privacy. This is problematic, as many youth may not understand the implications of the risks associated with digital connectivity, while they might be able to develop STEM skills. As a result, youth may not appreciate the broader context of the complexities of digital technology, particularly in navigating

online resources, which makes them susceptible to misinformation (Human Rights Council, 2023; Nan et al., 2022). Teaching youth how to identify and evaluate trustworthy sources of information, as well as how to differentiate between fact and opinion, can help them navigate the world of digital media with greater confidence, accuracy, and nuance (Hämäläinen et al., 2021; Magis-Weinberg et al., 2021).

Among the reviewed programs, the “Use, Understand, Create” initiative (Media Smarts, 2022) took a more holistic lens as it addressed these broader concepts of digital literacy (e.g., ethics, privacy, community engagement, and media literacy) in addition to digital skills. The Media Smarts team developed a comprehensive framework providing educators with guidance on how to incorporate these complex skills and topics into the classroom. While this program covers key aspects of digital literacy, the program is structured as classroom resources and lesson plans for educators, which requires specific training and skills to implement effectively—a potential implementation challenge. Flexibility in program delivery is a crucial consideration for appropriate implementation as well as uptake by youth (Nascimbeni & Vosloo, 2019; Oostermeijer et al., 2022). By ensuring that individuals with varying levels of training (i.e., educators with formal training to parents with limited technological experience) can successfully implement the program, our digital literacy program can be adopted in a range of settings due its flexibility and accessibility.

Despite the breadth of digital literacy curricula identified by our environmental scan, the majority of programs did not demonstrate flexibility in terms of mode of delivery and administration. This ability to adapt is especially important for improving the uptake, usability, and sustainability of digital literacy programs among youth, particularly as technology and the associated risks are constantly evolving (Nascimbeni & Vosloo, 2019). Based on the strengths and limitations of existing curricula, we developed a user-friendly program which could be delivered not only by educators in schools, but also by parents or other adults who could aid youth in understanding and applying the module content at home and/or other public settings (i.e., community centers). To ensure ongoing relevance of the program content, each module uses specific examples, which program administrators can tailor to their target audience to appeal to demographic diversity, geographic location, cultural relevance, or recent incidents based on the latest technological developments. For example, with recent advancements in AI (Bohr & Memarzadeh, 2020; Collins et al., 2021; Vinuesa et al., 2020), it is critical for youth to understand its applications in everyday life, potential benefits, as well as associated risks by including topics such as AI-driven advertising on social media which may use browser history data to push targeted ads (Bohr & Memarzadeh, 2020; Davenport et al., 2020). Another aspect of this adaptability is the format of delivery, as the digital literacy program can be delivered in-person, online, or via a smartphone-based app—further increasing the usability and sustainability of the content.

In addition to tailored examples and interactive content, a distinguishing factor of this digital literacy program is the emphasis on data sovereignty. Data sovereignty refers to meaningful control or ownership of one’s data (Bhawra et al., 2021; Hudson et al., 2023). Many smartphone-based apps and digital platforms unethically collect consumer data, leaving consumers with little to no control of how their data is used, stored, or repurposed (Anom, 2022; Hemker et al., 2021). This is especially problematic among

communities which have been historically colonized, including racialized and Indigenous Peoples (Hudson et al., 2023), whose personal information has often been misused particularly in the medical field (Goodman et al., 2017; Smye et al., 2023; Wylie & McConkey, 2019). Research indicates that users are more inclined to interact with and share data on online platforms that prioritize user control over their own data and place a strong emphasis on privacy (Prince, 2018). As a result, it is critical for consumers to be aware of their rights to data privacy and ownership, thus this digital literacy program emphasizes the control over data and connected concepts including consent and self-determination. By connecting digital privacy and safety to data sovereignty, the program empowers youth to understand their rights and make informed decisions about the data they share.

The impact of this digital literacy program will depend on several factors, including the implementation strategy, as well as broader contextual factors. Key considerations for implementation include: (i) setting (i.e., in your community, is this program best delivered in a school, community center, or other organization as part of extracurricular programming?), (ii) mode of administration (i.e., is it most feasible to deliver this program in-person or adapt for delivery online or via a mobile app?), and (iii) stakeholders (i.e., who is best suited to deliver this program in your community – educators, parents, etc.). Other contextual factors that need to be considered include available resources for administration and promotion of the program. While we found a range of resources and programming for digital literacy, there was little evidence of program evaluation (at least publicly available reports), which is an important factor in assessing the overall impact, design, and delivery of these programs (Reddy et al., 2023). Hence, we developed a digital literacy assessment tool to assess changes in literacy levels between pre- and post-program implementation. This tool will enable quantifying changes in digital literacy levels within a population both prior to and following program implementation. For example, individual-level change (i.e., specific improvements across module topic areas) can be empirically determined using statistical tests such as paired T-tests, which thereby allows program administrators and evaluators to determine the extent and type of impact the digital literacy program is having within a population.

Strengths and limitations

This study makes an important contribution to both the literature, as well as resources to practically apply and evaluate digital literacy among youth. The cross-disciplinary nature of this topic required flexibility in the search strategy, thus an environmental scan and literature review were selected as the primary methods to enable review of relevant organizational websites, grey literature, and reference lists as deemed relevant. However, it is possible that some relevant digital literacy programs and/or assessment tools may not have been captured by our search strategy, particularly given the geographic exclusion criteria limiting our search to Canadian programs and English language articles. Moreover, programs or curricula that did not explicitly frame the content as promoting ‘digital literacy’—but may have focused on related content such as data security—were likely also not captured by our search. While the developed digital literacy program and assessment toolkit is specific to address current gaps in Canada, both of these resources can be applied and/or adapted by other jurisdictions.

Conclusion

It is evident that digital literacy is a critical life skill for navigating today's digital world, and therefore requires dedicated educational strategies to ensure that youth are equipped with the skills to maximize its benefits while mitigating potential risks. Based on existing evidence and informed by foundational frameworks such as the UNESCO Digital Literacy Global Framework, this study developed a comprehensive digital literacy framework and assessment tool which could be used to evaluate the effectiveness of program implementation in a variety of settings, ranging from community centres to schools.

Given the growing importance of digital competencies, a youth-focused program and assessment tool are crucial for understanding and addressing digital literacy among this vulnerable cohort. While our study uncovered several promising programs and tools, it was evident that many lacked the flexibility and adaptability necessary to implement across varied settings. Our program's adaptability allows for customization to various sociodemographic target groups, including culturally diverse and geographically remote communities. Each module uses specific examples which can be tailored by program administrators for their target audience to appeal to demographic diversity or recent concerns (i.e., web-based scams, specific data privacy issue in a community), as well as the latest technological developments. Moreover, the corresponding assessment tool is necessary for ongoing evaluation and to enable ongoing improvements to digital literacy curricula for diverse populations of youth. Future work in this area will include a formal evaluation of both the newly developed digital literacy program and the assessment tool among Canadian populations. Additional research is required focusing on the development of a comprehensive global digital literacy program, which can be further adapted to specific jurisdictions and other vulnerable groups such as seniors. Overall, implementing digital literacy programs can better prepare youth for an increasingly digital world, while minimizing potential risks associated with technology use.

Abbreviations

ERIC	Education Resources Information Center
AI	Artificial intelligence
STEM	Science, technology, engineering, and mathematics
UNESCO	United Nations Educational, Scientific, and Cultural Organization
SDG	Sustainable Development Goal
NR	Not reported

Supplementary Information

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Additional file 1: 1. A tailored digital literacy program for youth. 2. A digital literacy assessment measure for youth.

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Author contributions

JB and TRK conceptualized this manuscript, MCB conducted the environmental scan and literature review, and MCB, JB and TRK conducted a review of all shortlisted programs and assessment tools, including creation of the final digital literacy program and assessment tool categories. All authors contributed to writing the full draft, reviewing, and approving the final manuscript.

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Availability of data and materials

All referenced digital literacy programs and assessment tools used to develop the current manuscript have been cited and summarized in the included data summary tables.

Declarations

Competing interests

The authors have no competing interests to declare.

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References

- Actúa. (2022). *Actua academy*. <https://actua.ca/actua-academy>
- Ahmed, S., Vaska, M., & Turin, T. C. (2016). Conducting a literature review in health research: Basics of the approach, typology and methodology. *Journal of National Heart Foundation of Bangladesh*, 5(2), 44–51.
- Animikii Inc. (2019). *Decolonizing digital: Contextualizing indigenous data sovereignty*. Animikii Indigenous Innovation. <https://www.animikii.com/news/decolonizing-digital-contextualizing-indigenous-data-sovereignty>
- Anom, B. Y. (2022). The ethical dilemma of mobile phone data monitoring during COVID-19: The case for South Korea and the United States. *Journal of Public Health Research*, 11(3), 22799036221102492. <https://doi.org/10.1177/22799036221102492>
- Aromataris, E., & Riitano, D. (2014). Systematic reviews: Constructing a search strategy and searching for evidence. *American Journal of Nursing*, 114(5), 49–56. <https://doi.org/10.1097/01.NAJ.0000446779.99522.f6>
- Aydin, M. (2021). Does the digital divide matter? Factors and conditions that promote ICT literacy. *Telematics and Informatics*, 58, 101536. <https://doi.org/10.1016/j.tele.2020.101536>
- Bach, A. J., Wolfson, T., & Crowell, J. K. (2018). Poverty, literacy, and social transformation: An interdisciplinary exploration of the digital divide. *Journal of Media Literacy Education*, 10(1), 22–41. <https://doi.org/10.23860/JMLE-2018-10-1-2>
- Bandura, R., & Leal, E. I. M. (2022). *The digital literacy imperative*. <https://www.csis.org/analysis/digital-literacy-imperative>
- Bhawra, J., Buchan, M. C., Green, B., Skinner, K., & Katapally, T. R. (2022). A guiding framework for needs assessment evaluations to embed digital platforms in partnership with Indigenous communities. *PLoS ONE*, 17(12), e0279282. <https://doi.org/10.1371/journal.pone.0279282>
- Bickham, D. S., Moukalled, S., Inyart, H. K., & Zlokower, R. (2021). Evaluating a middle-school digital citizenship curriculum (screenshots): Quasi-experimental study. *JMIR Mental Health*, 8(9), e26197. <https://doi.org/10.2196/26197>
- Bhawra, J., Skinner, K., Favel, D., Green, B., Coates, K., & Katapally, T. R. (2021). The food equity and environmental data sovereignty (FEEDS) project: Protocol for a quasi-experimental study evaluating a digital platform for climate change preparedness. *JMIR Research Protocols*, 10(9), e31389. <https://doi.org/10.2196/31389>
- Bohr, A., & Memarzadeh, K. (2020). The rise of artificial intelligence in healthcare applications. *Artificial Intelligence in Healthcare*. <https://doi.org/10.1016/B978-0-12-818438-7.00002-2>
- Boys and Girls Clubs of Canada. (2022). *What we do*. <https://www.bgccan.com/en/what-we-do/>
- British Columbia Ministry of Education and Child Care. (2022). *Digital literacy—A digital literacy framework*. Retrieved 3 August 2023, from <https://www2.gov.bc.ca/gov/content/education-training/k-12/teach/resources-for-teachers/digital-literacy>
- Burr, C., Taddeo, M., & Floridi, L. (2020). The ethics of digital well-being: A thematic review. *Science and Engineering Ethics*, 26(4), 2313–2343. <https://doi.org/10.1007/s11948-020-00175-8>
- Canada Learning Code. (2022). *Learning with us*. <https://www.canadalearningcode.ca/learning-with-us/>
- Casillas-Martín, S., Cabezas-González, M., & García-Valcárcel Muñoz-Repiso, A. (2020). Análisis psicométrico de una prueba para evaluar la competencia digital de estudiantes de Educación Obligatoria. *RELIEVE - Revista Electrónica De Investigación y Evaluación Educativa*. <https://doi.org/10.7203/relieve.26.2.17611>
- Charlton, P., Doucet, S., Azar, R., Nagel, D. A., Boulos, L., Luke, A., Mears, K., Kelly, K. J., & Montelpare, W. J. (2019). The use of the environmental scan in health services delivery research: A scoping review protocol. *British Medical Journal Open*, 9, e029805. <https://doi.org/10.1136/bmjopen-2019-029805>
- Chatterjee, D., & Corral, J. (2017). How to write well-defined learning objectives. *The Journal of Education in Perioperative Medicine*, 19(4), E610.
- Choi, M., Glassman, M., & Cristol, D. (2017). What it means to be a citizen in the internet age: Development of a reliable and valid digital citizenship scale. *Computers and Education*, 107, 100–112. <https://doi.org/10.1016/j.compedu.2017.01.002>
- Cooper, H., & Hedges, L. V. (2009). Research synthesis as a scientific process. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis* (2nd ed., pp. 3–13). Russel Sage Foundation.
- Collins, C., Dennehy, D., Conboy, K., & Mikalef, P. (2021). Artificial intelligence in information systems research: A systematic literature review and research agenda. *International Journal of Information Management*, 60, 102383. <https://doi.org/10.1016/j.ijinfomgt.2021.102383>
- Davenport, T., Guha, A., Grewal, D., & Bressgott, T. (2020). How artificial intelligence will change the future of marketing. *Journal of the Academy of Marketing Science*, 48(1), 24–42. <https://doi.org/10.1007/s11747-019-00696-0>

- Donelle, L., Facca, D., Burke, S., Hiebert, B., Bender, E., & Ling, S. (2021). Exploring Canadian children's social media use, digital literacy, and quality of life: Pilot cross-sectional survey study. *JMIR Formative Research*, 5(5), e18771. <https://doi.org/10.2196/18771>
- Drazich, B. F., Nyikadzino, Y., & Gleason, K. T. (2021). A program to improve digital access and literacy among community stakeholders: Cohort study. *JMIR Formative Research*, 5(11), e30605. <https://doi.org/10.2196/30605>
- Fraillon, J., Ainley, J., Schulz, W., Duckworth, D., & Friedman, T. (2019). IEA international computer and information literacy study 2018 assessment framework. *Springer International Publishing*. <https://doi.org/10.1007/978-3-030-19389-8>
- Goodman, A., Fleming, K., Markwick, N., Morrison, T., Lagimodiere, L., & Kerr, T. (2017). "They treated me like crap and I know it was because I was native": The healthcare experiences of Aboriginal Peoples living in Vancouver's inner city. *Social Science and Medicine*, 1982(178), 87–94. <https://doi.org/10.1016/j.socscimed.2017.01.053>
- Government of Canada. (2023). *Digital literacy exchange program*. <https://ised-isde.canada.ca/site/digital-literacy-exchange-program/en/digital-literacy-exchange-program>
- Government of Canada. (2016). *Security and prosperity in the digital age: Consulting on Canada's approach to cyber security*. <https://www.publicsafety.gc.ca/cnt/rsrscs/pblctns/2016-scrty-prsprty/2016-scrty-prsprty-en.pdf>
- Government of Ontario. (2022). *Strand a STEM skills and connections: Key changes—science and technology, grades 1–8*. Government of Ontario. <https://www.dcp.edu.gov.on.ca/en/sci-tech-key-changes/strand-a>
- Graafland, J. (2018). *New technologies and 21st century children: Recent trends and outcomes*. [https://one.oecd.org/document/EDU/WKP\(2018\)15/en/pdf](https://one.oecd.org/document/EDU/WKP(2018)15/en/pdf)
- Griffin, P., McGaw, B., & Care, E. (Eds.). (2012). *Assessment and teaching of 21st century skills*. Springer. <https://doi.org/10.1007/978-94-007-2324-5>
- Haddock, A., Ward, N., Yu, R., & O'Dea, N. (2022). Positive effects of digital technology use by adolescents: A scoping review of the literature. *International Journal of Environmental Research and Public Health*, 19(21), 14009. <https://doi.org/10.3390/ijerph192114009>
- Hadziristic, T. (2017). *The state of digital literacy in Canada: A literature review*. https://brookfieldinstitute.ca/wp-content/uploads/BrookfieldInstitute_State-of-Digital-Literacy-in-Canada_Literature_WorkingPaper.pdf
- Hämäläinen, E. K., Kiili, C., Räikkönen, E., & Marttunen, M. (2021). Students' abilities to evaluate the credibility of online texts: The role of internet-specific epistemic justifications. *Journal of Computer Assisted Learning*, 37(5), 1409–1422. <https://doi.org/10.1111/jcal.12580>
- Hatlevik, O. E. (2017). Examining the relationship between teachers' self-efficacy, their digital competence, strategies to evaluate information, and use of ICT at school. *Scandinavian Journal of Educational Research*, 61(5), 555–567. <https://doi.org/10.1080/00313831.2016.1172501>
- Hatlevik, O. E., Scherer, R., & Christophersen, K.-A. (2017). Moving beyond the study of gender differences: An analysis of measurement invariance and differential item functioning of an ICT literacy scale. *Computers and Education*, 113, 280–293. <https://doi.org/10.1016/j.compedu.2017.06.003>
- Hemker, S., Herrando, C., & Constantinides, E. (2021). The transformation of data marketing: How an ethical lens on consumer data collection shapes the future of marketing. *Sustainability*, 13(20), 20. <https://doi.org/10.3390/su132011208>
- Hudson, M., Carroll, S. R., Anderson, J., Blackwater, D., Cordova-Marks, F. M., Cummins, J., David-Chavez, D., Fernandez, A., Garba, I., Hiraldo, D., Jäger, M. B., Jennings, L. L., Martinez, A., Sterling, R., Walker, J. D., & Rowe, R. K. (2023). Indigenous peoples' rights in data: A contribution toward indigenous research sovereignty. *Frontiers in Research Metrics and Analytics*. <https://doi.org/10.3389/frma.2023.1173805>
- Human Rights Council. (2023). *Human Rights Council hears that digital, media and information literacy programmes should be considered an integral part of education efforts given their importance for the exercise of rights in the digital age*. United Nations. <https://www.ohchr.org/en/news/2023/07/human-rights-council-hears-digital-media-and-information-literacy-programmes-should-be>
- Jin, K.-Y., Reichert, F., Cagasan, L. P., de la Torre, J., & Law, N. (2020). Measuring digital literacy across three age cohorts: Exploring test dimensionality and performance differences. *Computers and Education*, 157, 103968. <https://doi.org/10.1016/j.compedu.2020.103968>
- Jones, L. M., Mitchell, K. J., & Beseler, C. L. (2023). The impact of youth digital citizenship education: Insights from a cluster randomized controlled trial outcome evaluation of the be internet awesome (BIA) curriculum. *Contemporary School Psychology*. <https://doi.org/10.1007/s40688-023-00465-5>
- Joshi, S. V., Stubbe, D., Li, S.-T.T., & Hilty, D. M. (2019). The use of technology by youth: Implications for psychiatric educators. *Academic Psychiatry*, 43(1), 101–109. <https://doi.org/10.1007/s40596-018-1007-2>
- Kannan, P., Bhawra, J., Patel, P., & Katapally, T. R. (2022). Preserving rural school health during the COVID-19 pandemic: Indigenous citizen scientist perspectives from a qualitative study. *AIMS Public Health*, 9(2), 216–236. <https://doi.org/10.3934/publichealth.2022016>
- Katz, I. R. (2007). Testing information literacy in digital environments: ETS's iSkills assessment. *Information Technology and Libraries*, 26(3), 3. <https://doi.org/10.6017/ital.v26i3.3271>
- Keach, S. (2014). *Ofcom tests your tech-savviness with new DQ quiz* | T3. <https://www.t3.com/news/ofcom-tests-your-tech-savviness-with-new-dq-quiz>
- Kelly, W., McGrath, B., & Hubbard, D. (2023). Starting from 'scratch': Building young people's digital skills through a coding club collaboration with rural public libraries. *Journal of Librarianship and Information Science*, 55(2), 487–499. <https://doi.org/10.1177/09610006221090953>
- Kids Code Jeunesse. (2022). *Resources for educators*. <https://kidscodejeunesse.org/resources-for-educators>
- Kim, M., & Choi, D. (2018). Development of youth digital citizenship scale and implication for educational setting. *Journal of Educational Technology and Society*, 21(1), 155–171.
- Kishore, K., Jaswal, V., Kulkarni, V., & De, D. (2021). Practical guidelines to develop and evaluate a questionnaire. *Indian Dermatology Online Journal*, 12(2), 266–275. https://doi.org/10.4103/idoj.IDOJ_674_20
- Korte, M. (2020). The impact of the digital revolution on human brain and behavior: Where do we stand? *Dialogues in Clinical Neuroscience*, 22(2), 101–111. <https://doi.org/10.31887/DCNS.2020.22.2/mkorte>

- Kusumawardani, E., Tristanti, T., & Kusumawardani, E. (2022). Digital literacy model to empower women using community-based education approach. *World Journal on Educational Technology: Current Issues*, 14(1), 175–188. <https://doi.org/10.18844/wjet.v14i1.6714>
- LaBonte, R., Nagle, J., & Barbour, M. K. (2021). *Pandemic pedagogy in Canada: Lessons from the first 18 months*. <https://canelearn.net/wp-content/uploads/2021/11/CANeLearn-Pandemic-Pedagogy-in-Canada.pdf>
- Law, N., Woo, D., de la Torre, J., & Wong, G. (2018). *A global framework of reference on digital literacy skills for indicator 4.4.2*. UNESCO. <https://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf>
- Lazonder, A. W., Walraven, A., Gijlers, H., & Janssen, N. (2020). Longitudinal assessment of digital literacy in children: Findings from a large Dutch single-school study. *Computers and Education*, 143, 103681. <https://doi.org/10.1016/j.compedu.2019.103681>
- Let's Talk Science. (2022). *Educational resources*. <https://letstalkscience.ca/educational-resources>
- Lupton, D. (2021). Young people's use of digital health technologies in the global north: Narrative review. *Journal of Medical Internet Research*, 23(1), e18286. <https://doi.org/10.2196/18286>
- Machete, P., & Turpin, M. (2020). The use of critical thinking to identify fake news: A systematic literature review. *Responsible Design, Implementation and Use of Information and Communication Technology*, 12067, 235–246. https://doi.org/10.1007/978-3-030-45002-1_20
- Magis-Weinberg, L., Ballonoff Suleiman, A., & Dahl, R. E. (2021). Context, development, and digital media: Implications for very young adolescents in LMICs. *Frontiers in Psychology*. <https://doi.org/10.3389/fpsyg.2021.632713>
- Maqsood, S., & Chiasson, S. (2021). Design, development, and evaluation of a cybersecurity, privacy, and digital literacy game for tweens. *ACM Transactions on Privacy and Security*, 24(4), 28:1–28:37. <https://doi.org/10.1145/3469821>
- Medhurst, K., Altrows, L., & Foreman, A. (2023). Establishing a common framework for digital skills in Canada recommendations report. https://bowvalleycollege.ca/-/media/bvc/school-of-continuing-learning/towes/recommendations_report.ashx?la=en&hash=E276AEDCBE604E207C570CC5C2550B0AD77F394F
- Media Smarts. (2022). *Use, understand and engage: A digital media literacy framework for Canadian Schools*. <https://mediasmarts.ca/teacher-resources/use-understand-engage-digital-media-literacy-framework-canadian-schools>
- Nan, X., Wang, Y., & Thier, K. (2022). Why do people believe health misinformation and who is at risk? A systematic review of individual differences in susceptibility to health misinformation. *Social Science and Medicine*, 314, 115398. <https://doi.org/10.1016/j.socscimed.2022.115398>
- Nascimbeni, F., & Vosloo, S. (2019). *Digital literacy for children: Exploring definitions and frameworks*. <https://www.unicef.org/globalinsight/media/1271/file/%20UNICEF-Global-Insight-digital-literacy-scoping-paper-2020.pdf>
- National Center for Educational Statistics. (2022). *More than 98 percent of public schools made concerted efforts to promote pandemic-related learning recovery during the 2021–22 school year*. https://nces.ed.gov/whatsnew/press_releases/08_04_2022.asp
- Nguyen, L. A. T., & Habók, A. (2022). Digital literacy of EFL Students: An empirical study in Vietnamese universities. *Libri*, 72(1), 53–66. <https://doi.org/10.1515/libri-2020-0165>
- Nicholas, H., & Ng, W. (2019). Mobile digital literacy of Australian adolescent students. *International Journal of Digital Literacy and Digital Competence*, 10(3), 32–48. <https://doi.org/10.4018/IJDLDC.2019070103>
- Nova Scotia Ministry of Education and Early Childhood Development. (2022). *High school technology education*. <https://curriculum.novascotia.ca/english-programs/technology-education>
- Office of the Privacy Commissioner of Canada. (2018). *For individuals*. <https://www.priv.gc.ca/en/for-individuals/>
- Oostermeijer, S., Williamson, M., Nicholas, A., Machlin, A., & Bassilios, B. (2022). Implementing and delivering youth mental health services: Approaches taken by the Australian primary health network 'lead sites'. *International Journal of Environmental Research and Public Health*, 19(17), 10494. <https://doi.org/10.3390/ijerph191710494>
- Pandya, A., & Lodha, P. (2021). Social connectedness, excessive screen time during COVID-19 and mental health: A review of current evidence. *Frontiers in Human Dynamics*. <https://doi.org/10.3389/fhumd.2021.684137>
- Paré, G., & Kitsiou, S. (2017). Chapter 9: Methods for literature reviews. In F. Lau & C. Kuziemsky (Eds.), *Handbook of eHealth evaluation: An evidence-based approach* (pp. 157–180). University of Victoria.
- Perdana, R., Yani, R., Jumadi, J., & Rosana, D. (2019). Assessing students' digital literacy skill in senior high school Yogyakarta. *JPI (Jurnal Pendidikan Indonesia)*, 8(2), 2. <https://doi.org/10.23887/jpi-undiksha.v8i2.17168>
- Pérez-Escoda, A., Jiménez-Narros, C., Perlado-Lamo-de-Espinosa, M., & Pedrero-Esteban, L. M. (2020). Social networks' engagement during the COVID-19 pandemic in Spain: Health media vs. Healthcare Professionals. *International Journal of Environmental Research and Public Health*, 17(14), 14. <https://doi.org/10.3390/ijerph17145261>
- Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences a practical guide*. Blackwell Publishing Co. <https://doi.org/10.1002/9780470754887>
- Pinnguaq. (2019). *Home*. Pinnguaq. <https://pinnguaq.com/>
- Prince, C. (2018). Do consumers want to control their personal data? Empirical evidence. *International Journal of Human-Computer Studies*, 110, 21–32. <https://doi.org/10.1016/j.ijhcs.2017.10.003>
- Quayyum, F., Cruzes, D. S., & Jaccheri, L. (2021). Cybersecurity awareness for children: A systematic literature review. *International Journal of Child-Computer Interaction*, 30, 100343. <https://doi.org/10.1016/j.ijcci.2021.100343>
- Quintana, M. G. B., Careaga-Butter, M., & Fuentes-Henriquez, C. (2020). Critical and prospective analysis of online education in pandemic and post-pandemic contexts. *Aloma: Revista De Psicología, Ciències De Leducació i De L'esport*, 38(2), 23–32. <https://doi.org/10.51698/aloma.2020.38.2.23-32>
- Reddy, P., Chaudhary, K., & Hussein, S. (2023). A digital literacy model to narrow the digital literacy skills gap. *Heliyon*, 9(4), e14878. <https://doi.org/10.1016/j.heliyon.2023.e14878>
- Richardson, S., Lawrence, K., Schoenthaler, A. M., & Mann, D. (2022). A framework for digital health equity. *NPJ Digital Medicine*, 5(1), 1. <https://doi.org/10.1038/s41746-022-00663-0>
- Rideout, V., Peebles, A., Mann, S., & Robb, M. B. (2022). *The common sense census: Media use by tweens and teens*. https://www.common sense media.org/sites/default/files/research/report/8-18-census-integrated-report-final-web_0.pdf

- Saxena, P., Gupta, S. K., Mehrotra, D., Kamthan, S., Sabir, H., Katiyar, P., & Sai Prasad, S. V. (2018). Assessment of digital literacy and use of smart phones among Central Indian dental students. *Journal of Oral Biology and Craniofacial Research*, 8(1), 40–43. <https://doi.org/10.1016/j.jobcr.2017.10.001>
- Schreurs, K., Quan-Haase, A., & Martin, K. (2017). Problematizing the digital literacy paradox in the context of older adults' ICT use: Aging, media discourse, and self-determination. *Canadian Journal of Communication*, 42(2), 359–377. <https://doi.org/10.22230/cjc.2017v42n2a3130>
- Secretariat, T. B., & Secretariat, T. B. (n.d.). *Smartphone use and smartphone habits by gender and age group, inactive—Open Government Portal*. Retrieved 25 July 2023, from <https://open.canada.ca/data/en/dataset/f62f8b9e-8057-43de-a1cb-5affd0a5c6e7>
- Shahid, M., & Turin, T. C. (2018). Conducting comprehensive environmental scan in health system and policy research: A process for assessing the subject matter landscape. *Journal of Biomedical Analytics*, 1(2), 71–80. <https://doi.org/10.30577/jba.2018.v1n2.13>
- Silveira, P., Morais, R., & Petrella, S. (2022). A communication study of young adults and online dependency during the COVID-19 pandemic. *Societies*, 12(4), 4. <https://doi.org/10.3390/soc12040109>
- Smye, V., Browne, A. J., Josewski, V., Keith, B., & Mussell, W. (2023). Social suffering: Indigenous peoples' experiences of accessing mental health and substance use services. *International Journal of Environmental Research and Public Health*, 20(4), 3288. <https://doi.org/10.3390/ijerph20043288>
- The Lancet Child and Adolescent Health. (2018). Growing up in a digital world: Benefits and risks. *The Lancet Child and Adolescent Health*, 2(2), 79. [https://doi.org/10.1016/S2352-4642\(18\)30002-6](https://doi.org/10.1016/S2352-4642(18)30002-6)
- Toronto Public Library. (2022). *Digital innovation hubs: Free access to technology, software and classes*. <https://www.torontopubliclibrary.ca/using-the-library/computer-services/innovation-spaces/>
- US Department of Education. (2018). *Technology and engineering literacy framework for the 2018 national assessment of educational progress*. <https://www.nagb.gov/content/dam/nagb/en/documents/publications/frameworks/technology/2018-technology-framework.pdf>
- van der Velden, M., & El Emam, K. (2013). "Not all my friends need to know": A qualitative study of teenage patients, privacy, and social media. *Journal of the American Medical Informatics Association : JAMIA*, 20(1), 16–24. <https://doi.org/10.1136/amiajnl-2012-000949>
- Vassilakopoulou, P., & Hustad, E. (2023). Bridging digital divides: A literature review and research agenda for information systems research. *Information Systems Frontiers*, 25(3), 955–969. <https://doi.org/10.1007/s10796-020-10096-3>
- Vernon, L., Modecki, K. L., & Barber, B. L. (2018). Mobile phones in the bedroom: Trajectories of sleep habits and subsequent adolescent psychosocial development. *Child Development*, 89(1), 66–77. <https://doi.org/10.1111/cdev.12836>
- Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Felländer, A., Langhans, S. D., Tegmark, M., & Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the sustainable development goals. *Nature Communications*, 11, 233. <https://doi.org/10.1038/s41467-019-14108-y>
- Waffenschmidt, S., Knelangen, M., Sieben, W., Bühn, S., & Pieper, D. (2019). Single screening versus conventional double screening for study selection in systematic reviews: A methodological systematic review. *BMC Medical Research Methodology*, 19, 132. <https://doi.org/10.1186/s12874-019-0782-0>
- Wylie, L., & McConkey, S. (2019). Insiders' insight: Discrimination against indigenous peoples through the eyes of health care professionals. *Journal of Racial and Ethnic Health Disparities*, 6(1), 37–45. <https://doi.org/10.1007/s40615-018-0495-9>
- Žerebecki, B. G., & Oprea, S. J. (2022). The direct and indirect effects of social technology use on children's life satisfaction. *International Journal of Child-Computer Interaction*, 34, 100538. <https://doi.org/10.1016/j.ijcci.2022.100538>

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