Applying Universal Design for Learning and the BC Digital Literacy Framework to Science Inquiry Projects

By

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Bachelor of Science, Simon Fraser University, 1997

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We acknowledge with respect the Lekwungen peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationship with the land continue to this day.

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Abstract

Using science inquiry projects as the vehicle, teachers can provide a personalized learning experience that is inclusive to all learners. Technology, which is integral to teaching and learning in today's classrooms, can contribute to personalized learning and presents an opportunity to help develop digital literacies skills. In British Columbia (B.C.), teachers are asked to integrate technology with little training or supporting curriculum, which means that digital literacy skills are not consistent among educators or students. With the help of existing frameworks, educators can design lessons that meet the needs of all learners while also teaching important digital literacy skills. The goal of this project is to provide a sample lesson plan for high school science inquiry projects that identifies relevant digital literacy skills, makes suggestions on how to facilitate the development of those skills, and promotes effective uses of student technology for personalized learning by implementing Universal Design for Learning (UDL).

Research literature on student technology use inside and outside of the class will be reviewed, as will recent research on the integration of technology to enhance or assist collaboration, inquiry, and personalized learning. The literature review will conclude with a review of research regarding two frameworks that will be implemented to integrate technology in B.C. high school science inquiry projects: the BC Digital Literacy Framework and UDL. By reflecting on and implementing these frameworks, educators may be better prepared to utilize technology in science inquiry projects to achieve more personalized learning. For this project, I will be using the BC Digital Literacy Framework and UDL in order to show how technology can be intentionally and effectively integrated into B.C. senior science classes to teach digital literacy skills and enhance personalization during inquiry projects.

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Chapter 1: Introduction

Most 21st century curricula include the integration of technology to enhance the acquisition, organization, communication, and demonstrating of knowledge. In spite of this expectation, little pre-service or in-service training is available to help teachers utilize technology effectively in their classroom. In British Columbia (B.C.), a supporting document, the BC Digital Literacy Framework (n.d.) is available that outlines digital literacy skills that are to be achieved for each range of grade levels (i.e., Gr. 3-5 or Gr. 10-12); however, guidance on *how* and specifically *when* to incorporate those skills into the curriculum is absent from curriculum documents. Some districts have documents that support student reflection of technology skills (Comox Valley School District No. 71, n.d., Coquitlam School District No. 43, n.d.); however, this still falls short of creating any requirements or accountability when it comes to the teaching of specific technology skills. Additionally, the BC Digital Literacy Framework document itself is not well known. Before this project I had never heard of this document, nor had many of the teaching colleagues I surveyed. It is because of this disconnect between expectations, training, and supporting resources that this project focuses on the effective implementation of technology to enhance personalized learning and digital literacy skills.

B.C. Curriculum Context

The mandate upon which the B.C. Curriculum for Kindergarten to grade 12 (K-12) is built around is "to enable learners to develop their individual potential and to acquire knowledge, skills, and attitudes needed to contribute to a healthy society and a prosperous and sustainable economy" (B.C. Ministry of Education, n.d.a., p. 4). This can be achieved by supporting students in developing their individual potential in three specific areas: intellectual development, human and social development, and career development. These three areas help characterize the

"educated citizen," which was introduced in the Statement of Education Policy Order in 1989 (B.C. Ministry of Education, Governance and Legislation Branch, 1989, D-88). The educated citizen is defined in the B.C. Ministry of Education's *Vision for Student Success* as having:

> **Intellectual Development** – to develop the ability of students to analyze critically, reason and think independently, and acquire basic learning skills and bodies of knowledge; to develop in students a lifelong appreciation of learning, a curiosity about the world around them, and a capacity for creative thought and expression.
>
> **Human and Social Development** – to develop in students a sense of self-worth and personal initiative; to develop an appreciation of the fine arts and an understanding of cultural heritage; to develop an understanding of the importance of physical health and well-being; to develop a sense of social responsibility, acceptance and respect for the ideas and beliefs of others.
>
> **Career Development** – to prepare students to attain their career and occupational objectives; to assist in the development of effective work habits and the flexibility to deal with change in the workplace. (B.C. Ministry of Education, n.d.e)

Details on *how* to support students in becoming an educated citizen have changed dramatically since 1989, largely due to the introduction and integration of technology in our daily lives.

B.C.'s new curriculum stresses the need to provide "opportunities to develop the competencies required to use current and emerging technologies effectively in all aspects of their learning and life" (B.C. Ministry of Education, 2015, p. 6). Technology is also instrumental when one considers the three categories of B.C.'s Core Competencies: communication, thinking and personal/social. The core competency of communication involves how individuals connect, collaborate and explain their accomplishments to others. The core competency of thinking

involves both creative and critical thinking. The core competency of personal/social involves fostering positive personal and cultural identity, social responsibility, and personal awareness.

By reviewing the characteristics that display each of the competencies (B.C. Ministry of Education, n.d.a, p. 2) it is evident that helping students become proficient and innovative users of technology is imperative to achieve B.C.'s education mandate. In order to support B.C. educators develop digitally literate learners, the BC Digital Literacy Framework outlines the characteristics of a digitally literate individual (B.C. Ministry of Education, n.d.d):

1. Research and Information Literacy
2. Critical Thinking, Problem Solving, and Decision Making
3. Creativity and Innovation
4. Digital Citizenship
5. Communication and Collaboration
6. Technology Operations and Concepts

When used in conjunction, the B.C. Curriculum and the BC Digital Literacy Framework can support and advise educators in B.C. by outlining the expectations and levels of understanding sought after for each grade level. It is important to recognize that *how* to teach students the skills of digital literacy remains the task set before educators, and although professional autonomy is highly valued by B.C. educators, more resources and direction are necessary for a consistent and successful integration of technology.

Digital literacy and technological proficiency must be intentionally incorporated and designed by educators in their lesson planning and should be woven throughout the curriculum to help develop educated citizens. Currently, standalone classes exist to develop technological skills (e.g., Applied Design, Skills, and Technologies curriculum, which includes Information and

Communications Technology courses such as Computer Studies 10). In order to fully develop the core competencies across the K-12 B.C. Curriculum, digital literacy skills need to permeate every class and every grade. The challenge for educators is that supporting documents (such as the BC Digital Literacy Framework) are not well known, and the professional development needed to support the integration of technology can be difficult to access. Additional challenges exist if each student does not have access to technology, or accessing technology is not reliable within the school itself. Tackling the reliability of network connections within schools or achieving a 1:1 technology to student ratio is beyond the abilities of educators; however, utilizing the mobile devices that many students have continual access to and developing lessons that encourage and promote digital literacy skills and enhance learning is achievable and is the focus of this paper.

Professional Journey and Relevance

It has been my experience that many students do not have sufficient digital literacy skills, and that these skills need to be modelled, taught, reinforced, and built upon, similar to traditional curriculum. Many students from K-12 have not received sufficient explicit instruction on *how* to use their mobile device as a tool for learning. As a parent of three teenagers and an educator for 22 years in middle and high schools in B.C., I have seen a diverse range of abilities and comfort levels that students (and educators) have with technology. Many students primarily use their devices for playing games and connecting with friends and family. In 2013, MediaSmarts conducted a survey of 5436 Canadian students in grades 4-11 and found the top three online activities were playing games, downloading or streaming music, shows or movies, and engaging in social networking sites (Steeves, 2014). For years, I have witnessed students unable to perform productive Google searches, unaware that they can use their social media to reach out to

experts for research, and uncertain of whether it is appropriate or allowed to use their handheld device to support their learning. Educators must not assume that their students are technologically literate or know how to use their devices for learning. If we do, we risk leaving some learners to flounder and be in the vulnerable position of admitting they might not have the technological skills that older generations mistakenly assume they have. Such an oversight could also lead to students endangering themselves online, or damaging their online footprint, putting future employment opportunities at risk.

It is my experience that many students are inexperienced when it comes to using their technology for learning which is not surprising when we recognize that some schools have banned the use of mobile devices entirely in an effort to minimize student distractions. These schools have taken away student agency and the independence to look up vocabulary when they need to, investigate their curiosities, and find research to defend or correct their understanding. Rather than banning technology (which avoids teaching the self-regulation skills that will be required for students to succeed) teachers can help students transition from using their mobile devices primarily as social tools to harnessing the educational advantages and opportunities that their mobile devices can afford.

The availability of technology in schools is often cited as an obstacle to using technology and teaching digital literacy skills. This can be partially rectified if teachers promote the use of student's handheld devices for learning in the classroom. In addition to promoting the use of handheld devices for learning, this can also promote personalized learning for the student as they are often more comfortable navigating their own device instead of an unfamiliar assigned iPad or Chromebook.

Inquiry projects are another way that educators can enhance personalized learning. With careful lesson development and design, educators can address learner variability by integrating flexible options in a proactive way rather than a reactive way. Technology can be used to further personalize the learning and teach important digital literacy skills. Planning for inclusive and personalized learning in this way can lead to improved learning and engagement for all students.

Research Problem

It is expected that technology skills be taught in B.C.'s K-12 public education system and that educators provide more personalized learning opportunities for students (B.C. Ministry of Education, n.d.b, p. 1). Integrating technology can be challenging as mobile technology is often discouraged or banned in an effort to minimize distractions and the use of various apps and software are often restricted by districts in an effort to protect student privacy. These obstacles or restrictions can limit opportunities for personalized learning, as it has been shown that technology can significantly contribute to and enhance personalized learning (Reigeluth et al., 2015). The result is that many teachers and learners do not have the confidence, knowledge, experience, or support to integrate technology effectively and personalized learning opportunities are lost.

Research Question

In order to meet the expectation of promoting digital literacy skills educators will need to embrace technology and tackle the aforementioned challenges with confidence. To achieve this, I will investigate the research problem: How can science inquiry projects be designed to promote personalized learning while enhancing digital literacy skills?

Project Overview

The purpose for this paper is to identify effective uses of technology for teaching and learning in senior science classes, and provide examples for the intentional integration of mobile devices to enhance personalized learning. Rather than simply modelling effective use of mobile devices as learning tools, I will show how to incorporating technology intentionally and effectively into lesson plans by employing Universal Design for Learning (UDL) in conjunction with the BC Digital Literacy Framework. In this way, educators can reveal to learners the full potential of their mobile devices as a learning tool, and can help students achieve the characteristics of the 'educated citizen'.

Search Methods

My search was initially limited to the University of Victoria's (UVic) online summons database, using Boolean search methods to search terms such as, but not limited to: educational technology, high school or secondary school, individualized instruction or individualized learning, differentiated instruction or differentiated learning, personalized instruction or personalized learning. Additional searches included social media use, educational technology frameworks, UDL, collaboration, inquiry, inquiry-based learning, open learning, digital literacy, and digital citizenship. As my research progressed, my search expanded to include the ERIC database, online scholarly searches, and open journals, and regularly included reading referenced articles from my research.

Search parameters used in the UVic summons database included publications from the past five years and peer and scholarly reviewed articles. Of primary interest was research relevant to middle and high school science classes and educational research from British Columbia and Canada, although other research (including research older than five years) was

included when deemed relevant. Research that focused solely on integrating a specific type of technology was not included in this literature review (for example, iPad or Livescribe pen).

Definition of Terms

While many definitions of relevant terms are described in the literature review that follows, here is list of a few important terms and also some relevant comparisons of similar terms to assist the reader.

21st century learning. The term "21st century learning" emerged as it became clear that the skills being taught during the industrial age were no longer deemed as relevant in the age of modern technology. In the article "What knowledge is of most worth: Teacher knowledge for 21st century learning" Kereliuk et al. (2013) divide 21st century skills into 3 categories: Foundation, Meta and Humanistic. Foundational knowledge includes core curriculum and knowledge, digital literacy skills, and cross disciplinary knowledge. Meta knowledge includes problem solving and critical thinking, communication and collaboration, and creativity and innovation. Humanistic knowledge incudes life skills, job skills and leadership, cultural competence, and ethical and emotional awareness. These three categories of 21st century skills are strongly reflected in the new B.C. Curriculum.

Personalization. Personalization is the process of making something suitable for the needs and levels of individual students. There is considerable ambiguity around the conceptualization and implementation of personalized learning, however common characteristics include using adaptive technologies, ubiquitous learning, scaffolding learning to the level of knowledge or interest of the learner, and student autonomy over how, when and where to learn (Zhang, et al., 2020) For the purpose of this paper, personalization is applied to learning rather

than personalized instruction. The system in which most B.C. educators teach is still organized with a high student to teacher ratio and personalized instruction is simply not attainable.

Learner-centered. The National Research Council (2000a) states: "learner-centered environments pay careful attention to the knowledge, skills, attitudes, and beliefs that learners bring to the educational setting" (p. 3). Learner-centered environments include learners in the decision making of how and what will be learned and how it will be assessed, hence learners are co-creators and partners in the entire learning process.

Flexible learning. The foundation of flexible learning is providing choice to learners (Soffer et al., 2019). Flexible learning environments may, for example, provide flexible timelines, content, entry requirements, resources, or delivery methods.

Inquiry and inquiry-based learning. For the purpose of this project, inquiry or inquiry-based learning (IBL) will refer to "an educational activity in which students are placed in the position of scientists gathering knowledge about the world" (Keselman, 2003, p. 898). IBL is a learner-focused teaching strategy that encourages the personal construction of knowledge rather than the transfer of knowledge from teacher to student. Pedaste et al. (2015) describe five phases of IBL in their systematic literature review of the core features of IBL: conceptualization, investigation, exploration, investigation and discussion. This type of learning requires the co-construction of knowledge, strong problem-solving skills, active participation in the learning process, and the application of authentic scientific discovery.

Mobile device. For the purpose of this study, the term mobile device will include any portable technology that has access to the internet. This includes, but is not limited to, portable devices such as smart phones, laptops, iPads, Chromebooks, or tablets.

Open educational resources. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) defines open educational resources (OER) as "teaching, learning or research materials that are in the public domain or released with intellectual property licenses that facilitate the free use, adaptation and distribution of resources" (n.d., para. 1).

Formal and informal learning. Formal learning (in the context of K-12 education as opposed to workplace training) typically refers to traditional stand-and-deliver teaching methods. Generally, this type of learning requires a significant amount of effort on the part of the learner compared to its apparent usefulness or relevance. The depth of understanding, the time spent learning, the learning activities and the learning applications are prescribed by the teacher. Informal learning occurs when:

> learners decide what they need to learn and then establish their own learning objectives and agenda. In addition, learners determine when they should learn, and select the format and modality that best meets their needs. Perhaps most importantly, the learner is responsible for organizing and managing his or her own learning-related activities. (Boileau, 2017, p. 187)

It follows that informal learning is often more engaging for students, is viewed as more relevant, and contributes to the development of lifelong learning skills.

Chapter 2: Theoretical Framework and Literature Review

The goal of this project is to integrate digital literacy skills and identify the effective uses of mobile devices for personalized teaching and learning during inquiry projects in B.C. high school science classes. I will begin this Chapter with an overview of social constructivism, the theoretical framework which supports my research and to my approach to teaching and learning. In the literature review that follows student technology use inside and outside of the class will be discussed as will recent research on the integration of technology to enhance or assist collaboration, inquiry and personalized learning. Chapter 2 will conclude with a review of relevant research regarding two frameworks that will be implemented to integrate technology in B.C. high school science class: the BC Digital Literacy Framework and Universal Design for Learning. By reflecting on and implementing these two frameworks a lesson plan for a high school science inquiry project will be developed using UDL to achieve personalized learning.

Theoretical Framework: Social Constructivism

Constructivism is a theory that supports the notion that learners are actively constructing their own knowledge as they interact with their surroundings and reflect on their experiences. Teachers that practice constructivism in the classroom will understand that individual students brings their own experience and knowledge to learning experiences and will encourage the development of ideas and concepts through student-centered activities and collaborative learning. The two major types of constructivism are cognitive constructivism, developed by Piaget (1950), and social constructivism, developed by Vygotsky (1978). Cognitive constructivism is focused on the individual learner and how one's knowledge is formed through mental or cognitive processes, whereas social constructivism emphasizes that learning and knowledge are constructed while interacting with others.

The theoretic framework that serves as the foundation for this project is social constructivism, the theory that knowledge is actively constructed by the learner through critical thinking and interacting with others. This is in line with the practices of scientific inquiry, collaboration, and IBL.

Literature Review

Student Technology Use

Statistics for technology in schools in Canada are very scarce. Statistics Canada released "The digital divide in Canadian Schools" in 2003 (Government of Canada), and the "Canadian Internet Use Survey" in 2019 (Government of Canada), however there are no further statistics from Statistics Canada to draw from. The "Canadian Internet Use Survey" is not specific to schools, however it did reveal that 94% of Canadian households had home internet access.

MediaSmarts, a Canadian charitable organization that supports digital and media literacy, partnered with the Canadian Teachers' Federation and produced a comprehensive document that included a variety of surveys on student technology use in 2016. The document explores the availability of networked technologies in the classroom, how teachers are using networked technology to support learning, teacher knowledge and skills of networked technology, and creative uses of networked technology. Some of the key findings of this document were that the vast majority of teachers value and use networked devices in the classroom, however "the personal devices that students are least often permitted to bring to class are also the ones they are most likely to use when allowed" (Johnson et al., 2016, p 19). This highlights the importance of encouraging and teaching students the self-regulation skills that will help them take control of their technology use, and view their personal devices as learning tools rather than simply social and/or gaming tools.

It is important that Canada and B.C. continue to collect important data regarding technology in schools so that educators and policy makers have a clear picture of obstacles that may exist when planning for and implementing technology use in the classroom. Information involving student technology use is required to make informed decisions regarding equity of learning opportunities, both inside and outside of the classroom. Further research can also reveal which skills are most important for the workplace, what the current level of technology proficiency is amongst students and teachers, and how technology skills might be most effectively introduced to or further developed by educators.

As student demographics and local environments vary widely, it is recommended that educators familiarize themselves with the availability of and accessibility to technology in their particular area. A media release by the Greater Victoria School District on June 20, 2017, stated that $1.25 million was invested to achieve a 4:1 ratio of student to technology device in schools (Greater Victoria School District, 2017). During the COVID 19 pandemic in the spring of 2019 the Greater Victoria School District distributed over 1000 iPads and Chromebooks to students, which had a total student enrollment of over 18000 students. Our school collected information specific to our student population during the COVID-19 pandemic by conducting a school-wide survey in the spring of 2019. The survey received 610 responses (out of a high school population of 1118) and it was found that 99.3% of students had access to a mobile device at school (99.3% had access to a cell phone, 38.8% had access to a laptop, and 9.7% had access to a tablet) and 99.2% had a device at home that allowed them to access the internet. Considering that 90 Chromebooks were signed out to students in April of 2020 (during the initial lockdown of the COVID-19 pandemic), it is clear that several students that did not have access to a device did not respond to the survey, reflecting the necessity of provincial, district, and administrative support

for students that do not have access to technology. Further studies are needed to reveal exactly how many B.C. students have access to technology and internet both at home and at school.

Canadian statistics on teen use of technology is scarce and infrequent; however, the MediaSmarts national survey published an article that revealed a few interesting trends regarding student technology use (Steeves, 2014). The survey reported that 99% of students could access the internet outside of school, 85% of grade 11 students had their own smart phone, and students preferred portable devices over desktop computers. These statistics might suggest that spending district money on buying more computers may not be where the majority of money should be invested. Providing professional development for teachers and helping teachers integrate technology that facilitates using mobile devices for learning could further encourage the development of technology skills *and* inspire students to use their mobile devices as life-long learning tools.

A study that reviewed existing research on how social networking sites were being used in education found ample research that had been conducted on common uses of networking technology in schools, however, little research had been conducted on networking technology's effectiveness at improving student learning (Greenhow & Askari, 2015). Although sites like Facebook, Snapchat, and Instagram are used primarily for connecting with friends, learners could be introduced and encouraged to use networking sites to connect with experts and people with similar academic interests. Prior to using technology for this purpose discussions need to occur with students in order to facilitate digital literacy and digital citizenship, however the benefits of expanding one's academic and professional network can be substantial. Some benefits include exposure to different cultures and beliefs, introductions to leading experts, the promotion of informal learning and knowledge building and access to up-to-date information and

resources. It is important to introduce students to the multitude of ways one can conduct research and learn new information besides performing Google searches, however it is equally important to educate students on how to use technology safely and responsibly.

Student Health and Digital Citizenship

Caring adults, including educators, must be engaging in discussions with young people about online safety, health and wellness, and resiliency when it comes to using technology. Discussions regarding online privacy and security, the prevalence of online data collection, and the use of increasing complex and effective software algorithms that try to monopolize the attention of technology users can contribute to students making informed decisions about their technology use.

Concerns about student depression, anxiety and cyberbullying persist in Canadian schools and in Canadian homes. Adults must be intentional and proactive in modeling, teaching, and monitoring positive technology use amongst our youth. This cannot be accomplished by banning mobile devices from school. It can only be accomplished by teaching students how to effectively and responsibly use the powerful learning tool they possess, and by engaging students in productive and positive online behaviors that can foster independent learners with a positive and confident ‘can-do’ mindset.

Technology for Learning

Informed integration of technology in schools can have many positive impacts on the learning environment and the learner’s experience. Technology can be used to access free resources, collaborate with experts in your neighborhood or around the world, and allow for immediate and collaborative feedback by peers, teachers or experts. Technology can also be used to provide accommodations and adaptations that meet the needs of all learners, provide choice

for teachers and learners in how they access educational content and also how they show their learning and understanding. Many of these advantages to technology utilize OER. Listed below are some of the benefits and challenges of using technology to access OER, and then a review of the literature regarding using technology for collaboration, using technology for inquiry, and using technology to enhance personalized learning is conducted.

Open Educational Resources. Technology is allowing teachers and students to access a wealth of free and educational information using OER. OER is changing the landscape of education and allowing learners to access textbooks, lessons, courses, articles, videos and other resources at no cost if they have a technology device and the internet. With access to OER, students no longer need to depend on expensive journal subscriptions to access academic research and they do not need to limit their educational pursuits according to the availability or accessibility of courses.

OER have the potential to support and encourage self-directed and independent learning, which are qualities that can contribute to lifelong learning. The article “From OER to open pedagogy: harnessing the power of open” suggests that OER have become platforms for learning, collaboration, and engagement with the world outside the classroom and that they can empower our students to contribute to the online marketplace of ideas and to the scientific community (DeRosa & Robison, 2017). DeRosa and Robison conclude by encouraging an exciting next step of participation in OER: “When we think about OER as something we do rather than something we find/adopt/acquire, we begin to tap their full potential for learning” (p. 122).

OER enables students to access and be inspired by a wider variety of material. These resources can help remove the financial barrier and burden of accessing information and can

promote lifelong and informal learning. OER can also support educators as they work to promote 21st century skills, such as critical thinking, problem solving, innovation, collaboration, communication and self-directed learning. The ability to access, use and adapt OER encourages a higher level of learner, where “the learning happens not through the consumption of the content but through the use of the content” (Gašević et al., 2015, p. 5).

Educators and users should be aware of the challenges and downsides of OER. Educators must consider accessibility, both inside and outside of the classroom, if they are assigning work or encouraging informal learning. Students may not own a device or have permission to bring a hand-held device to school. They may not have a computer at home or access to the internet or may face unforeseen technical issues that can frustrate both students and teachers. Providing alternatives or solutions to these challenges is essential for educators in order to be successful at implementing the use of technology and OER in the classroom. Without such consideration and sensitivity, educators stand to promote exclusion rather than inclusion, and will fail to empower young learners.

Another challenge or potential risk that educators face when using OER involves data collection and the privacy of students. A recent study found that young people focus on interpersonal aspects of online privacy but rarely think about institutional contexts (the data that a school, doctor, or the government might hold) or commercial contexts (Stoilova et al., 2020). Teaching our students to be aware of who has access to their data and minimizing such risks is an important life lesson in digital literacy. The risks of small start-up companies selling student data for extra revenue, the criminal activity of mass hacking of student data, and even smaller scaled pranks are today’s realities when using technology and one must be informed and aware.

Another cause for consumer awareness when using OER is the fact that OER are in the public domain and can be freely adapted and shared. Although this is one of the qualities that make OER so powerful, it also requires that users think critically about which sources they trust. Concerns about the lack of standardized quality monitoring has been documented in research (OPAL, 2011), and continues to be a barrier for educators to fully embrace OER (Archambault, 2020). Much like navigating the internet and identifying fake news, students and educators must exercise their digital literacy as they are left to determine the quality and value of OER.

It is particularly interesting to consider the future of OER in K-12. In the article "Openness and Praxis: Exploring the Use of Open Educational Practices in Higher Education" Cronin (2017) attempts to scaffold openness in education. Descriptions of the following 'types of opens' can be helpful for understanding OER, and can also inspire further explorations in openness:

- Open admission: eliminates entry requirements for access to learning (Open Universities)
- Open as Free: allows the user to access educational resources at no cost (MOOCs, YouTube, TED Talks)
- OER: allows the user to retain, reuse, redistribute, revise and remix resources (Wiley et al., 2014)
- Open educational practices (OEP): are defined by Cronin as "collaborative practices that include the creation, use, and reuse of OER, as well as pedagogical practices employing participatory technologies and social networks for interaction, peer-learning, knowledge creation, and empowerment of learners" (Cronin, 2017, p. 18).

Fully employing OEP involves privacy issues that may not always be suitable for K-12; however, investigation of OEP and implementation on a small scale with strict privacy settings might be an interesting area of development and research in K-12 settings.

Online Collaboration. Online collaboration is an area where educators can utilize the prevalence of social media use amongst teens to enhance the global knowledge-building that technology can support. Student use of social media technology can add a critical component to collaborative learning that can assist students with the co-construction of knowledge, both in and out of the classroom, while building the digital literacy skills necessary in society and many workplaces. More specifically, mobile devices provide several opportunities and benefits that traditional computers do not: they provide a more personalized learning interface, instant messaging capabilities, and allow for portability and interconnectivity of learning devices (Sung et al., 2017).

It is well established that collaboration has a positive effect on learning and retention (Bertucci et al., 2010). Knowledge building and collaboration have the potential to extend the learning so that the community can accomplish more than any one individual. Technology adds yet another dimension to collaboration. A meta-analysis conducted on the role of computer-supported collaborative learning (CSCL) found that students had improved skill acquisition, knowledge gains, social interactions and group task performance when they participated in collaborative gameplay and learned in small groups (Chen et al., 2018).

Although these claims are very enticing, potential pitfalls for using technology to enhance collaborative learning environments must be identified and avoided. Kreijns et al. (2003) point out that students will likely need incentive to participate regularly in CSCL environments for the purpose of critical thinking and knowledge construction. Assigning specific

tasks within the face-to-face and the on-line learning environment (such as describing, explaining, and predicting), and fostering positive interdependence while requiring individual accountability can assist in the promotion of productive interactions (Johnson & Johnson, 1989, 1999; Ohlsson, 1996). It has been identified that group targets, individual responsibility, and group interaction are essential factors for effective collaboration (Slavin, 1996) and should be explicitly modeled, facilitated, and assessed by the teacher. Heinstrom and Sormunen (2016) found that loose course design, short time frames, and lack of instructional guidance prevented students from experiencing successful collaborations. Another potential pitfall includes students that rely too heavily on their peers and do not contribute equally to learning tasks. In addition to identifying individual tasks, care when considering group size and composition can minimize 'free-riders.' A fourth pitfall is jumping into online collaborations too quickly. Students must feel safe and supported before they will engage in collaborative learning, hence teachers must be deliberate in their efforts to create a supportive learning environment where students feel safe, respected, and experience a sense of belonging. This can best be achieved when students are encouraged to get to know each other and participate in the social dimensions of online learning communities while embarking on their educational pursuits.

Extending student social media skills and interests to intellectual pursuits such as networking and collaboration allows learners to access a global community of experts, be active participants of a larger learning community, and continue their learning beyond school hours and traditional classrooms.

Inquiry. Inquiry is a process that supports students in developing a scientifically-oriented question, building on their existing knowledge to find answers or explanations, and then present their findings to an audience. Educators that promote inquiry as a method of teaching might

boast about how it better engages students, promotes expert-level knowledge acquisition, encourages independent learning and strengthens presentation skills (Mackenzie, 2016; Sadeh, et al., 2009; Bevins, et al., 2016). It resembles the scientific method (first documented in 1621 by Sir Francis Bacon) and employs higher level thinking by requiring that students observe, question, gather and analyze information, infer, predict, test or challenge existing knowledge, compare and interpret their results and discuss evidence. First, I will outline the process and levels of inquiry, then present research that supports the implementation of IBL in science. Finally, I will present the argument that inquiry in education can be enhanced by the use of mobile technology.

IBL has 'stolen the show' in science education for the past 20 years, but the application of philosophies that support inquiry being applied to education date back over 100 years to Dewey and Schwab (as discussed in Schwab's book *The Teaching of Science as Enquiry* (1962). Schwab introduced these four steps of the inquiry process:

1. Develop a question of interest
2. Research the chosen topic and apply knowledge effectively
3. Present your process and findings
4. Reflect on your learning.

Schwab further believed that science classes should be modeled after science as practiced by professional scientists and that this could be facilitated by progressing through three levels of inquiry: structured, guided and open inquiry. The higher the level of inquiry, the more student involvement and autonomy there is. Sadeh and Zion (2009) found that structured inquiry was insufficient in developing student's critical and scientific thinking skills; however, their research found that guided and open inquiry were equally effective at developing inquiry skills and

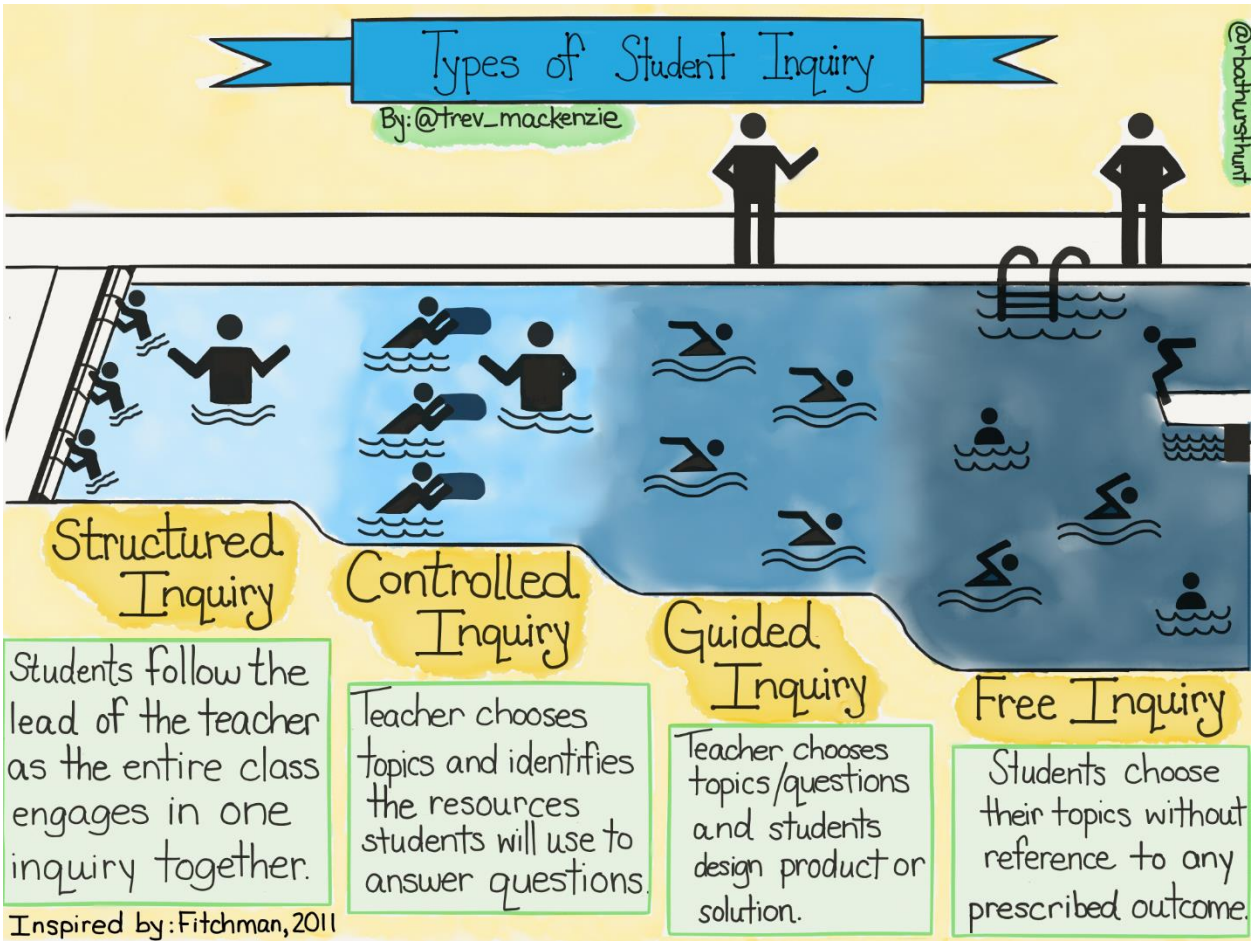
critical thinking. It is important to note that Sadeh and Zion emphasize the critical role that teachers play in IBL and that teachers who are closely involved in the process were instrumental in the acquisition of scientific inquiry skills.

Kirschner et al. (2006) further document and support the important role that teachers play in IBL. Based on human cognitive architecture, Kirschner et al. predict that minimally guided instruction is likely to be ineffective, and after examining the research they conclude that not only is it less effective; there is evidence that it may have a negative influence on student learning. Educators need to support students in developing their inquiry skills such as identifying a problem or question for investigation, planning an outline for learning, and navigating the immense volume of information available. Enthusiastic teachers that respond to individual student skills, knowledge, and attitudes and teach the inquiry process with strong instructional guidance will be most effective in helping students be successful with IBL.

From the findings of Sadeh and Zion and Kirschner et al., one can conclude that beginning with structured inquiry is important to teach the process of inquiry; however, a thoughtful progression to guided inquiry is necessary for students to develop inquiry skill and critical thinking. Mackenzie (2016) details the process of planning an inquiry unit by starting with a structured inquiry unit and gradually increasing student agency as learners acquire higher level thinking skills and knowledge.

Figure 1

Types of Student Inquiry



Note: This figure shows how the four levels of inquiry increase in difficulty from structured inquiry to free inquiry as the teacher transitions from that of director of learning to facilitator of learning. From Mackenzie, T. (2016). *Dive into inquiry: Amplify learning and empower student voice*. EdTechTeam Press, p. 28.

Although the process of inquiry had been implemented by scientists since the 1600's and educators and students since the 1960's, it was not until 2000 that the National Research Council published a report that examined the research-base of inquiry-based teaching in school science. This was done in an effort to help educators implement and justify inquiry-based approaches. The findings conclude that inquiry assists learning for understanding rather than simply knowing

facts (National Research Council, 2000b). Such understanding can enable learners to apply knowledge to novel situations. Further conclusions include:

1. Inquiry facilitates scientific thinking, including making careful observations, problem solving, reasoning and analysis.
2. Inquiry is effective at correcting student misconceptions and preconceptions, resulting in conceptual change
3. Inquiry results in a more positive student view of science and scientific explanations.
4. The social component of inquiry (involving sharing of ideas) further promotes learning and idea reconstruction.
5. Inquiry facilitates personal accountability, independent learning, and metacognition.

The effective implementation of scientific inquiry in schools continues to be scrutinized, researched, and modified. In the article titled "Reconceptualising inquiry in science education," it is suggested that inquiry should have three components rather than the traditional four steps, as traditional methods restrict students' experience of authentic inquiry in an effort to make assessment and classroom management easier (Bevins & Price, 2016). Bevins and Price suggest scientific inquiry be broken down into three components: scientific knowledge (includes facts and theories), evidence-generating and handling procedures (includes data gathering and analysis), and psychological energy (includes intrinsic and extrinsic motivation). As educators and researchers continue to question and investigate the implementation of inquiry in science, alongside the inclusion of modern technologies and conveniences, new approaches to the process of inquiry will continue to develop and improve.

Regardless of the approach to IBL, the use of mobile devices and technology can assist in the process of scientific inquiry. Now that research on every imaginable topic is made widely

available through OER, graphing and modeling software is at one's fingertips, collaboration tools are convenient and easy to navigate, and networking with experts in the field is just a tweet, email or friend request away, inquiry can be conducted anytime and anywhere by anyone.

Technology can contribute significantly to IBL as it allows greater access to information, enhances student motivation and engagement, improves communication and networking, and enables a range of creative possibilities for presenting one's learning. Technology also allows students to continue their learning outside of the classroom and promotes student independence. Technology skills learned during the inquiry process are also valuable in-and-of themselves as such skills easily transfer to 'the real world' and the workplace.

In summary, inquiry can promote the understanding of scientific concepts and the ability of students to "do" science when executed in an effective learning environment. Ultimately, this can lead to the reorganization and expansion of one's scientific understanding, critical thinking, and problem-solving skills.

Personalized Learning. Personalized Learning is a familiar concept in B.C.'s education system. The British Columbia Teachers Federation (BCTF) conducted a year-long consultation on public education in 1968 and introduced their report with the conclusion that education should be "personalized" (BCTF online museum, 1968). Almost 50 years later, the new B.C. Curriculum states that "one focus for this transformation is a curriculum that enables and supports increasingly personalized learning, through quality teaching and learning, flexibility and choice, and high standards" (B.C. Ministry of Education, n.d.c, para. 2).

Personalized learning stems from the idea that in order to motivate learners and make learning meaningful, the material must have personal relevance. Since Dewey presented the notion of making learning student-centered several theoretical frameworks have been constructed

to evaluate the educational outcomes of personalized learning such as expectancy-value theory (Eccles et al., 2020) and self-determination theory (Struyf et al., 2017). The variety of frameworks presents challenges when one tries to summarize the research, however a common theme persists throughout the implementation of such frameworks of personalized learning: it is challenging to personalize the learning experience of each student within a system that is designed to teach same-aged learners the same content at the same time, and assess them based on grade-level expectations. In fact, such assessments might actually serve to measure the effectiveness of the institution itself rather than the educational progress of its learners.

Personalized learning allows curriculum to be more culturally relevant, more interesting and of increased perceived usefulness to the learner, and takes into account the unique needs of each individual. The new B.C. Curriculum is contributing to easier and more effective implementation of personalized teaching and learning by providing flexibility for deeper learning opportunities through concept-based and competency-driven approaches. The B.C. curriculum further supports personalization with a strong focus on critical thinking, creative thinking, and social and personal responsibility.

An example of personalization in the public sector is given in the article “Personalised Learning: Ambiguities in Theory and Practice” (Campbell et al., 2007). Many of the insights and conclusions made in this article can be extended to the education sector. When discussing a 23% decline in heart disease in England between 1997 and 2002, it is shown that once citizens adopt changes to their lifestyle and when care becomes personalized:

> the state does not act upon society; it does not provide a service. Instead, the state creates a platform or environment in which people make decisions about their lives in a different way This is a bottom-up, mass social innovation enabled by the state. (p.16)

Extending his example to education would look like this: school (teachers) would not act upon society (students), rather it would create a platform where learners could identify their weakness(es), access relevant information, build upon their knowledge and develop the confidence to self-manage their learning.

The emphasis in personalized learning is on student voice and choice, helping learners understand how they learn most effectively, and enabling people to reach their own personal goals and potential. Campbell et al. suggest that such reform in the education system would be most effective when a whole school approach is implemented and teacher professional development is rigorous, and they also assert that deep personalization can be envisaged most easily with older and more able students.

In order to successfully shift from a standardized education system to a personalized education system, technological tools are imperative for collaboration, accessing research, and information, and creating culturally relevant learning artifacts. Technology can also help students organize and manage their learning, learn metacognitive skills, and allow access to information anytime and anywhere (Reigeluth et al., 2015). Without technology, Reigeluth et al. claim it would be difficult for educators to truly personalize learning.

It is my goal to improve personalized learning experiences by utilizing mobile technology, drawing from my experience and knowledge of OER, collaborative learning and inquiry, and applying the frameworks of UDL and the BC Digital Literacy (each of which will be introduced and discussed in the following section).

Supporting Frameworks

BC Digital Literacy Framework

It has been noted that there are important considerations that need to be taken when using technology such as ensuring accessibility for all learners, being critical of the reliability and validity of resources, preserving one's mental health, and protecting one's privacy and data.

For the purpose of this paper, The BC Digital Literacy Framework will be implemented however a multitude of frameworks are available (for a detailed analysis of 10 digital literacy frameworks, see *Analysing Digital Literacy Frameworks* by Rosado and Belisle, 2006). The BC Digital Literacy Framework was constructed in 2013 by Dr. Tim Winkelman and a team from the B.C. Ministry of Education. The intention of the document was to remove content from the equation and define characteristics of digital literate students; however, I believe it can also be an effective tool to assist, guide, and assess curriculum development.

The Government of B.C. (B.C. Ministry of Education, n.d.d) states that digital literacy is an important skill to have in today's technology-based world, and defines the characteristics of digital literacy as:

1. Research and Information Literacy
2. Critical Thinking, Problem Solving, and Decision Making
3. Creativity and Innovation
4. Digital Citizenship
5. Communication and Collaboration
6. Technology Operations and Concepts.

These six characteristics are based on the National Educational Technology Standards for Students standards developed by the International Society for Technology in Education (ISTE, n.d.).

Digital Literacy is defined by BC's Digital Literacy Framework as "the interest, attitude and ability of individuals to use digital technology and communication tools appropriately to access, manage, integrate, analyze and evaluate information, construct new knowledge, and create and communicate with others" (B.C. Ministry of Education, n.d.d, p. 1, para. 2). Digital literacy can sometimes be used synonymously with digital citizenship, however digital citizenship is just one characteristic of becoming digitally literate. As described by the BC's Digital Literacy Framework, digital citizenship is the ability to "understand human, cultural, and societal issues related to technology and practice legal and ethical behaviour" (p. 1). For example, as relevant sources expand beyond citing books, magazines, and journal articles, digital citizens need to be aware of a spectrum of copyright options regulating access and reuse. Traditional instruction on giving attribution and copyright laws must be expanded upon in order to educate learners of the range of possibilities that an owner of intellectual property may authorize, especially with OER. To take this one step further, students also need to be aware of their rights as creators and be aware of the different ways they can license their intellectual property.

An important and sometimes challenging characteristic of digital literacy in K-12 is privacy and security. Different districts have their own policies on which software and learning management systems they allow and/or promote. Even with endorsement from a district, students, parents, and teachers alike need to be educated on the risks associated with divulging personal information when using technology. Caines and Glass (2019) warn of the risks

associated with using digital tools (in education and otherwise) and advise educators to model and promote informed decision making when it comes to sharing personal data. Caines and Glass graciously offer the following statement and questions for reuse and/or remixing to help students become better informed users of technology (para. 7):

> Your personal data is valuable and important, which is why it is often collected by the digital tools you use in your educational activities. To better understand how and why your data is collected, the potential risks of this collection, and how to better protect your personal data, consider asking yourself the following questions:
>
> - What types of personal data do you think are collected through your use of digital tools for educational activities?
> - What value does your personal data have for different contexts and entities? Consider how your data might be valued by your instructor, the institution, yourself, and companies.
> - Who owns your personal data, who can sell it, and who can use it?
> - Do you have concerns about how your personal data can be used? If so, what are they?
> - Are there aspects of your identity or life that you feel would put you in a place of special vulnerability if certain data were known about you or used against you?

Digital Literacy must also be considered by educators when communicating with parents or guardians. With respect to digital reporting, the BCTF has specific policy for its members (BCTF Research, 2017).

> Policy 51.C.09.01: digital programs for reporting and communication with parents should only be used when Privacy Impact Assessments have been developed and district, school, and classroom policies have been defined and are followed
>
> Policy 51.C.09.02: district, school, and classroom policies should include definitions of how the data will be used during the time that it is being collected (e.g. a school year), whether it will be saved and accessible after the current use, and, if so, who has access to that data, and a plan for how and when the data will be destroyed.
>
> Policy 51.C.09.05: all data created by a student should be recognized as belonging to the student, and not to the provider of the program, nor should it be used for any commercial purpose nor linked to other education, government, or commercial databases. (p. 159)

The fact that there is policy regarding privacy impact assessments, data collection, and the ownership of data, does not mean that teachers are informed on how to uphold the policies. A survey of BCTF members in 2017 shows that 85% of responding teachers have little or inadequate training on privacy issues and concerns related to digital reporting systems (BCTF Research, 2017). Professional development opportunities for educators on digital literacy will need to be made available and encouraged if all K-12 educators are expected to educate learners on the same.

When choosing to use or endorse educational applications, even if a privacy impact assessment has been conducted by a school district, educators must be cautious as school systems have long since been the target for educational technology. Selwyn et al. (2019) predict that "the global digital education agenda will continue to be influenced by big corporate 'edu-businesses' such as Pearson alongside wealthy philanthropics such the Chan Zuckerberg Initiative" (p. 3) and as such, educators need to be skeptical of the intentions of big business and

keep the ideals of public education as a primary focus when using technology. It is important to note that economics and data collection are closely related, as personal data can now be used and sold for substantial profit.

Last but not least, when using technology to build relationships and communicate, many students still need guidance on how to use technology appropriately, ethically and respectfully. Guiding learners towards the safe and respectful use of social media, ensuring our students do not fall victim to, or contribute to cyberbullying and advising users how to handle inappropriate or concerning online behaviours are essential lessons for technology users. Through modeling, guiding and monitoring online posts, educators can encourage positive and responsible networking that can contribute to powerful learning communities.

Given the prevalent role of technology in education and the abundant research that documents the benefits of technology use in today's classroom, educators have a responsibility to ensure that our students are informed and responsible technology users. For some educators, this may include significant learning and/or professional development in the area of technology and digital citizenship. I am confident this is time well spent (and money well invested) as all of today's citizens need to be proficient and confident when choosing and implementing appropriate technology when they research, problem solve, create and communicate.

Universal Design for Learning Framework

Coined in the early 1980's by Architect Ronal Mace, the origins of universal design began as a way to improve accessibility for all with features such as curb cuts in sidewalks to improve accessibility for wheelchairs, strollers or bicycles. More recently, universal design has been embraced by the educational community in an effort to improve every individual student's accessibility to the curriculum, assist in instructional planning, and improve student engagement.

Many universal design frameworks exist; however, for the purpose of this project the UDL framework, created in 2006, will be used as it provides a structure that supports learning by taking into account brain science and the interaction of the recognition, strategic, and affective networks of the brain.

When UDL is used in digital learning environments research has shown that academic outcomes and student engagement improve (Hall et al., 2015, Al-Azawei et al., 2016). It has become so pivotal in learning design that in the United States UDL is part of the Individuals with Disabilities Education Act (IDEA) of 2004 and is embedded in the Higher Education Opportunity Act of 2008. Although most research is focused on how UDL meets the needs of students with disabilities, intentional lesson planning and development using UDL will provide the flexibility that supports all learners. By anticipating and reducing the barriers of learning for students teachers can support learners and foster inclusivity.

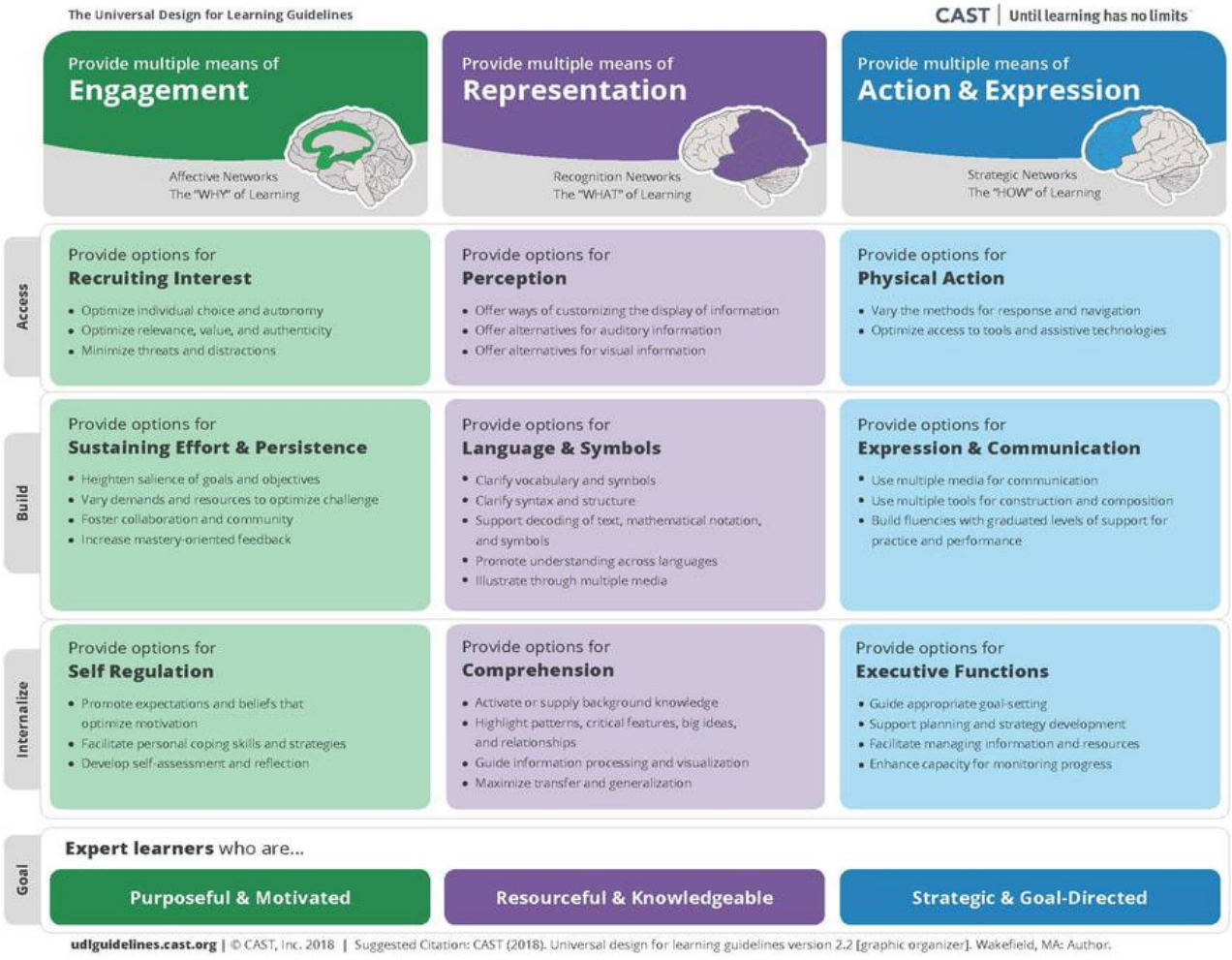
The three principles of UDL are:

1. Provide Multiple Means of Representation
2. Provide Multiple Means of Action and Expression
3. Provide Multiple Means of Engagement

Each of these three principles is supported by three guidelines to support access to information, building on information, and internalizing information.

Figure 2

Universal Design for Learning



CAST (2018). *Universal design for learning guidelines version 2.2 [graphic organizer]*.Wakefield, MA: Author.

It has been asserted that the UDL framework can assist the educational progress of a range of students, and more specifically it has been shown that when coupled with assistive technologies such as text-to-speech or word prediction software it can support students with disabilities (Messinger-Willman & Marino, 2010). With UDL learner variability can be

anticipated and lessons can be intentionally designed to provide flexible learning pathways that support the diverse backgrounds, needs and abilities of all students.

In each stage of lesson development UDL reminds educators to consider and respond to the following 3 questions:

- How can the teacher encourage the development of expert learners who are purposeful and motivated?
- How can the teacher encourage the development of expert learners who are resourceful and knowledgeable?
- How can the teacher encourage the development of expert learners who are strategic and goal-directed?

Rao and Meo (2016) expand upon these three driving questions and provide a process of lesson development designed to help teachers utilize UDL. The four processes of lesson development outlined by Rao and Meo include developing goals, designing opportunities for assessment, considering instructional methods and providing materials, resources and tools. My professional project will follow this process of lesson development to create a science inquiry project that will provide students options for flexible and personalized learning pathways.

Conclusion

A common theme through the research conducted for this project was that student autonomy and flexible learning opportunities are imperative for personalized learning, and that personalized learning can be significantly enhanced by the integration of technology. Technology has a key role to play in facilitating every student's educational progress, whether it be developing the skills associated with inquiry projects, providing opportunities for networking, or harnessing the potential for personalized learning. To facilitate technology integration

educators can refer to and apply the BC Digital Literacy Frameworks and the UDL framework in order to thoughtfully and effectively teach technology skills that can enhance personalized learning.

Chapter 3: Applying UDL and BC Digital Literacy Framework

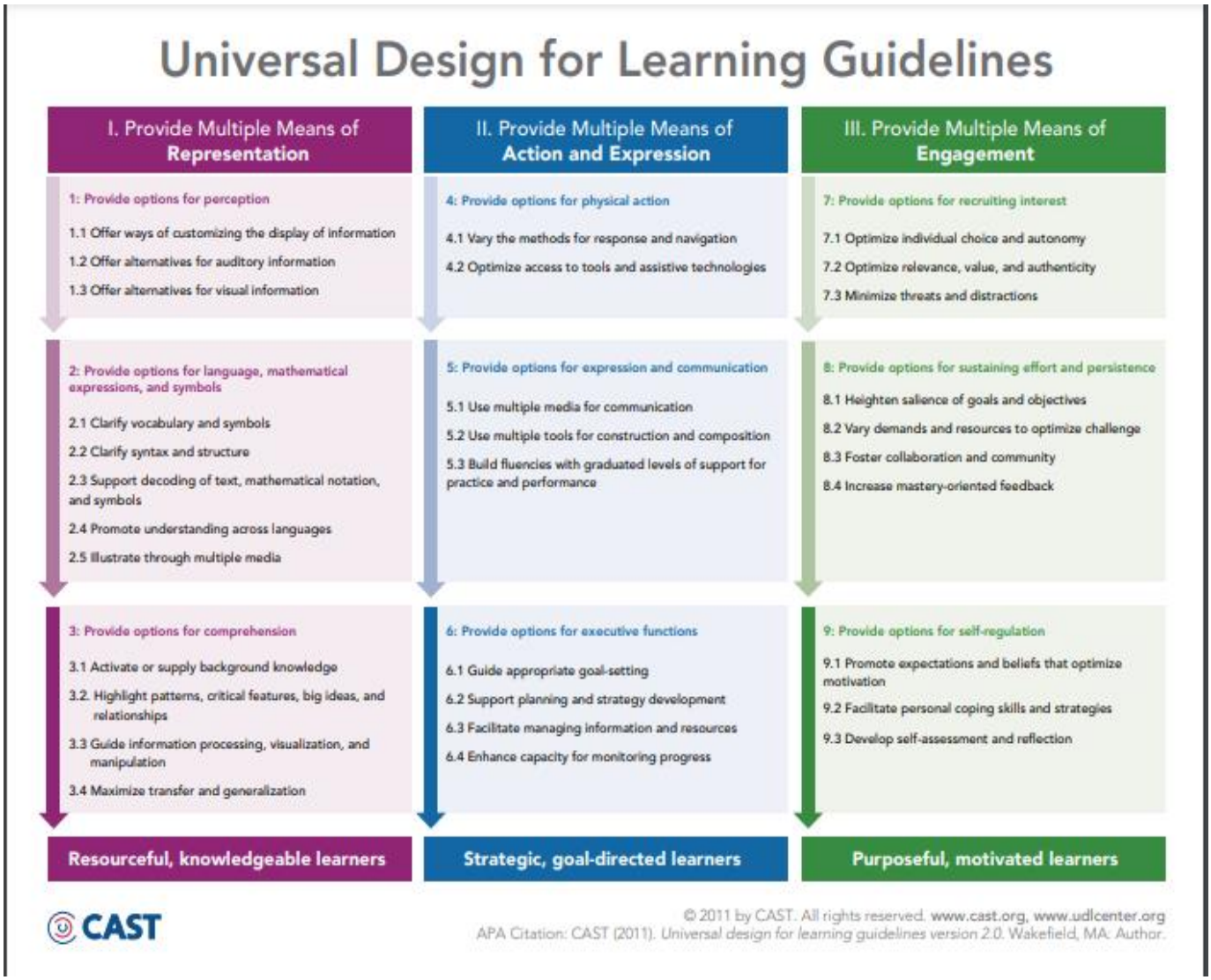
For my professional project, I will consider a standard science 10 inquiry project that utilizes technology with the intention of providing personalized learning experiences. I will develop the project using the UDL, and then refer to the BC Digital Literacy Framework to determine where opportunities exist for teaching digital literacies.

Applying UDL to Science Inquiry Projects

UDL offers a set of guidelines (see Figure 5) to help teachers consider multiple means of representation, action and expression, and engagement. Four components of developing a lesson are goals, assessments, methods and materials. There is no prescriptive way to apply UDL, rather it is up to the educator to incorporate UDL in a way that best suites them. In this project, I will be considering the aforementioned four components, and reviewing the UDL guidelines to consider how the guidelines can be incorporated and implemented in each component of lesson development of a science 10 inquiry project. By engaging in this process, I will provide examples of how to provide flexible learning environments that can support student's academic and emotional needs. The final earth science inquiry project student handout, check-in and reflection that have been developed through this process can be found in Appendix A, B, and C respectively.

Figure 3

Universal Design for Learning Guidelines



CAST (2018). *Universal design for learning guidelines version 2.2 [graphic organizer]*. Wakefield, MA: Author.

First, I will consider how to apply UDL to the development of goals for a unit, and then will apply UDL to the development of assessments, methods and materials.

Step 1: Goals. What are the Skills and Concepts we Want Students to Master?

In B.C., the provincial learning standards for science 10 are provided in the B.C. Curriculum. In order to design lessons and learning that are accessible for all students, clear goal statements will be constructed that identify the skills, concepts, and UDL guidelines that are addressed.

Skill goals for this science 10 astronomy inquiry project include:

- Students will demonstrate their learning of the formation of the universe in written, oral or multimedia format
- Students will utilize astronomical data and identify collection methods (technology) to describe an aspect of the formation of the universe

Concept goals (curricular competencies) for this science 10 astronomy inquiry project include:

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of interest
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Communicate scientific ideas, claims, information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations

For the UDL guidelines addressed in the development of these goals and a summary of how each guideline was integrated in the inquiry project see Table 1.

Table 1

Developing Inquiry Goals Using UDL

Guideline	Guideline subsection	Summary of how guideline was met
Guideline 5: Provide options for expression and communication	5.1 Use multiple means for communication	5.1 Several options for demonstrating learning are presented with the final method for demonstration of learning being up to the student.
Guideline 6: Provide options for executive functions	6.1 Guide appropriate goal-setting	6.1 How to demonstrate student learning is presented in a goal-setting manner. For example, students are encouraged to choose a method that is in-line with future aspirations and/or build on personal skills and interests.
	6.2 Support planning and strategy development	6.2 Planning and strategy development skills and options are presented step by step in the student inquiry handout. For example, develop an inquiry topic, develop an inquiry question, plan your time backwards from the due date, prepare your method of recording resources and synthesizing information, etc.
	6.3 Facilitate managing information and resources	6.3 Suggestions are given for how to navigate a variety of sources and manage large amounts of information. For example, a recording sheet for resources and synthesizing information is available.
	6.4 Enhance capacity for monitoring progress	6.4 To help monitor project progress and encourage a sustained interest in a scientific topic, daily written check-ins for in-class learning are conducted and there are regular one-to-one conversations between teacher and student during class.
Guideline 7: Provide options for recruiting interest	7.1 Optimize individual choice and autonomy	7.1 Students choose their topic, how they present their learning, which resources they use, how they record their resources and synthesize the information, and what app, add-on, website or guidance they utilize to construct their bibliography. (Note: many examples are given for each of these, and students are encouraged to reach out during class or via email for help or guidance)
	7.2 Optimize relevance, value, and authenticity	7.2 Various opportunities for student choice are given for each step of the inquiry process.
	7.3 Minimize threats and distractions	7.3 To minimize threats or student anxiety, students are encouraged to email the teacher questions and share their work using technology. A quiet, working atmosphere in class should be maintained. Student reflections are conducted during class that include considering how to minimize distractions such as social media.

Guideline 8: Provide options for sustaining effort and persistence	8.2 Vary demands and resources 8.4 Increase mastery-oriented feedback	8.2 In planning their time, students are encouraged to block their time into sections of a) determining their inquiry question and presentation method b) research using a variety of sources and c) creating their final presentation 8.4 Peer and/or teacher feedback is required for each in-class learning day. Each day, the teacher will circulate and provide feedback to individual students Students are encouraged to submit their projects for feedback prior to their final presentation.
Guideline 9: Provide options for self-regulation	9.1 Promote expectations and beliefs that optimize motivation 9.2 Facilitate personal coping skills and strategies	9.1 Skills that will assist them in their future endeavors are emphasized. For example, presentation skills, technology skills, communication and collaboration skills for feedback, and formatting skills for written works and bibliographies. 9.2 Daily student check-ins provide an opportunity to discuss and brainstorm how to problem solve through feelings of frustration, distraction and overwhelm.

Note. This table demonstrates the UDL guideline that have been addressed while developing goals for a unit and gives examples of how these guidelines could be incorporated into a science inquiry project.

Step 2: Assessments. How Can Students Demonstrate Their Learning?

In order to design lessons and learning that are accessible for all students, the following formative and summative assessments will be conducted in accordance with the following UDL guidelines:

Formative assessments for this science 10 astronomy inquiry project are:

- Teacher will circulate each class to discuss inquiry questions, research development, and project development
- Student is required to have either a peer or the teacher proofread their work and receive feedback prior to final presentation

Summative assessments for this science 10 astronomy inquiry project are:

- Teacher will evaluate student learning through presentations and project submission (in a format of the student's choosing). Teacher will provide a rubric with clear criteria that can be used in any format of presentation

For the UDL guidelines addressed in these formative and summative assessments and a summary of how each guideline was integrated in the inquiry project see Table 2.

Table 2

Developing Formative and Summative Assessments for Inquiry Using UDL

Guideline	Guideline subsection	Summary of how guideline was met
Guideline 5: Provide options for expression and communication	5.1 Use multiple means for communication	5.1 Formative assessment: students will receive feedback from their peers and/or the teacher as they develop their project. This will be done either face-to-face during class or by emailing or sharing their work using technology.
	5.2 Use multiple tools for construction and composition	5.2 Summative assessment: Student presentations can be in a written format, an oral presentation (completed with or with technology), or pre-recorded audio or visual presentation.
	5.3 Build fluencies with graduated support for practice/performance	5.3 Formative assessment: options for collaborative technology tools and presentation formats will be discussed with the teacher during daily check-ins. Instruction will be given on a one-to-one basis in response to student needs and interests. Summative assessment: Teacher will provide a rubric with clear criteria when the inquiry project is introduced. This can be referred back to regularly by students and/or teachers to guide progress (formative assessment)

Note. This table demonstrates the UDL guideline that have been addressed while developing formative and summative assessments and gives examples of how these guidelines could be incorporated into a science inquiry project.

Step 3: Methods. How can we Best Support and Structure Lessons?

In order to design lessons and learning that are accessible for all students, the following instructional strategies will be implemented in accordance with the following UDL guidelines:

- Students will be provided a variety of formats for instruction and learning. Word recognition software will be used, such as Google Read and Write.
- Students will develop their inquiry projects with the assistance of step-wise supports provided by the teacher
- Teacher will suggest formats of instruction or provide personal instruction as needed while conducting daily check-ins
- As a whole group activity, teacher and students will practice accessing open scholarly articles and journal subscriptions through the school library
- As a whole group activity, teacher and students will conduct advanced google searches and practice using Google scholar
- As a whole group activity, teacher and students will practice writing citations and references

For the UDL guidelines addressed in these methods a summary of how each guideline was integrated in the inquiry project see Table 3.

Table 3

Developing Methods of Instruction for Inquiry Using UDL

Guideline	Guideline subsection	Summary of how guideline was met
Guideline 1: Provide options for perception	1.1 Offer ways of customizing the display of information	1.1 Lessons are available in both paper format and on the google classroom Step-by-step directions are written out, and a student check-list is provided
	1.2 Offer alternatives for auditory information	1.2 Lessons are discussed as a group and individually as needed.
	1.3 Offer alternatives for visual information	1.3 Google Read and Write or Kurzweil Education's assistive technologies are offered, which includes text to speech software. *Check with your inclusive education department to see what technology is available at your school as alternatives for visual and/or auditory information
Guideline 2: Provide options for language, mathematical expressions, and symbols	2.3 Support decoding of text	2.3 Many students will be unfamiliar with the format of scientific journals, therefore the teacher will go through an example and highlight the importance of the abstract, conclusion, number of citations, etc.
	2.4 Promote understanding across languages	2.4 Closed captioning in alternate languages will be offered as they are available. The use of translators is encouraged.
	2.5 Illustrate through multiple media	2.5 Relevant videos and/or online tutorials are offered to provide addition instruction on the inquiry process.
Guideline 3. Provide options for comprehension	3.1Activate or supply background knowledge	3.1 Teacher facilitates discussion on inquiry, how to conduct an inquiry project, and how students have used inquiry in their everyday lives
	3.2 Highlight patterns, critical features, big ideas, and relationships	3.2 Teacher facilitates discussion on patterns and relationships between inquiry and the scientific method
	3.3 Guide information processing, visualization, and manipulation	3.3 Teacher facilitates group and individual discussions that help visualize the inquiry process and synthesize research
Guideline 4: Provide options for physical action	4.1 Vary the methods for response and navigation	4.1 Students have autonomy over how they conduct their research. The teacher will offer suggestions, such as interviews, articles, web searches, etc.
	4.2 Optimize access to tools and assistive technologies	4.2 Teacher has technology available (PC's and/or Chromebooks)

Note. This table demonstrates the UDL guideline that have been addressed while developing methods of instruction for a unit and gives examples of how these guidelines could be incorporated into a science inquiry project.

Step 4: Materials. What Resources, Materials and Tools can we use?

In order to design lessons and learning that are accessible for all students, the following materials, resource and tools will be available in accordance with the following UDL guidelines:

Teacher will support the student-selected format for developing and expressing learning by

- having Chromebooks and/or personal computers available
- facilitating access to the library and librarian
- suggesting networking opportunities
- suggesting or providing graphic or physical organizers to plan, make notes, record references and summarize information

For the UDL guidelines addressed in the offering of these materials, resources and a summary of how each guideline was integrated in the inquiry project see Table 4.

Table 4

Developing Materials and Resources for Inquiry Using UDL

Guideline	Guideline subsection	Summary of how guideline was met
Guideline 1: Provide options for perception	1.1 Offer ways of customizing the display of information 1.2 Offer alternatives for auditory information 1.3 Offer alternatives for visual information	1.1 Lesson materials are available in both paper format and on the google classroom Step-by-step directions are written out, and a student check-list is provided 1.2 Lesson materials are discussed as a group and individually as needed 1.3 Teacher offers Google Read and Write or Kurzweil Education's assistive technologies. *Check with your inclusive education department to see what technology is available at your school to offer alternatives for visual and/or auditory information
Guideline 4: Provide options for physical action	4.2 Optimize access to tools and assistive technologies	4.2 Teacher has technology available (PC's and Chromebooks) Teacher has access to assistive technology Teacher will liase with the librarian and the inclusive education department to facilitate access to Kurzweil and a variety of research tools.
Guideline 5: Provide options for expression and communication	5.2 Use multiple tools for construction and composition	5.2 Teacher discusses relevant technology for project planning (Trello, Microsoft or Google Calendar), managing information (Google docs, Google sheets, windows, handwritten templates for summarizing research and recording references), and learning presentations (Powtoon, slide presentations, animations, video production, etc.) Teacher provides options for doing research, for example interviews, documentaries, newspaper articles, journal articles, etc.

Note. This table demonstrates the UDL guideline that have been addressed while developing materials and resources for a unit and gives examples of how these guidelines could be incorporated into a science inquiry project.

To conclude this portion of my project on the application of UDL to science inquiry projects I have included a final reflection template for teachers as appendix D. This reflective practice can help teachers consider their educational practices, student participation and student engagement, and can contribute to future improvements in the inquiry process.

Applying the BC Digital Literacy Framework to Science Inquiry Projects

The use of technology is woven throughout this science 10 inquiry project. The BC Digital Literacy Framework can be referred to and applied to help educators and students use technology safely and effectively. Following each of the four steps of the inquiry process, examples are provided for developing digital literacies using the BC Digital Literacy Framework.

Step 1: Develop a Question

When developing an inquiry question the teacher can focus on three specific digital literacies: research and information literacy, critical thinking, problem solving and decision making, and communication and collaboration.

Research and Information Literacy. Students will need to search and navigate the wealth of information on the internet in order to narrow in on a personal topic of interest and identify which sites are valuable and reliable sources of information. Resources for teaching this digital literacy include:

- Triangulation (finding three resources that are in agreement or report the same findings
- Online document: Criteria for Evaluating Internet Resources (Kehoe, 2009)
- Online document: University of California, Berkeley: Evaluating Resources (Berkeley Library, n.d.)
- Online Document by ISTE - Today's News: Real or Fake? (ISTE, 2017)
- Your school librarian may have resources already developed that show students how they can judge the validity and reliability of resources

In order to conduct an effective internet search students will also need to identify important keywords. Often students, even in the senior grades, struggle to conduct effective searches. This

skill can be modelled throughout a course by encouraging students to conduct searches in response to higher level questions posed by both the teacher and students, and comparing keywords used and the results those keywords elicit.

Another digital literacy that falls under research and information literacy is the ability to conduct searches other than simple Google searches. This might include using Google Scholar, performing advanced Google searches, accessing open resources (such as open journals and textbooks), and accessing journals that their educational institution has subscriptions to. In order to facilitate this skill, teachers can introduce and help students navigate academic journals that are subscribed to by the school. This will inevitably lead to a discussion of OER and students can be directed to the Directory of Open Access Journals (DOAJ) or similar directories. This process can provide another valuable opportunity for collaboration with your school librarian.

Students will need to begin recording sources of information that may/will contribute to their final project. Teaching bibliography citation rules and introducing apps or software that can assist with bibliography citations early will benefit students. (Yet another opportunity to collaborate with your librarian!) A few online bibliography and citation tools include:

- EasyBib
- Zotero or ZoteroBib
- Citation Machine
- Bibme
- The American Psychological Association offers handouts and guides for APA style references and citations (American Psychological Association, n.d.)

Critical Thinking, Problem Solving and Decision Making. Once an area of interest is identified, the student must think critically and creatively to develop a higher level question.

Students will also need to identify authentic problems and significant questions for investigation. Conducting effective keyword searches and using a variety of search techniques can assist students with developing higher level inquiry questions. If students are not familiar with higher level thinking and questioning, introducing them to Costa and/or Bloom's taxonomy of gathering, processing and applying information can help them identify and develop higher level thinking skills.

Students will need to plan and manage activities to complete a project. This can be facilitated by providing templates for recording resources, or students may choose to use a digital planning tool such as Google Calendar or Microsoft Outlook calendar, Trello, or Todoist.

Communication and Collaboration. Developing a higher-level inquiry question will often require collaboration between teacher and student, student and peers, and/or student and experts in the field. Teachers can facilitate the development of this digital literacy by encouraging students to share their potential inquiry questions and helping them identify authentic higher level questions. Many students may be more inclined to share their questions with you via email, and some may be more comfortable getting feedback from peers. Both of these should be encouraged after a foundation of helpful and respectful communication has been established.

Students can also be encouraged to ask questions of experts in the field via face-to-face interviews, phone interviews, or using social media apps such as Twitter. If students choose to interact with experts, whether using technology or not, student safety in these situations is paramount. Topics such as professionalism, privacy and security, and digital footprints should be thoroughly discussed.

Step 2: Research and Apply

Research and Information Literacy. To further research and information literacy (in addition to the suggestions noted above) I require that students select information from at least 2 sources that are not found through a simple Google search be referenced. Students will also need to organize, synthesize and ethically use information from a variety of sources. Organizing and synthesizing information well can contribute to ethical use of information that does not impinge on copyright rules. Lessons on how to effectively summarize information can be helpful for students, as this is an acquired skill that needs to be developed. Subsequent notes and summaries of research can be collected by the teacher to encourage the synthesis of information and also can discourage plagiarism.

Critical Thinking, Problem Solving and Decision Making. Students may choose to create knowledge representations for their projects using digital media. Examples of digital mind mapping and image tools include (but are not limited to) Apache's OpenOffice Draw, Canva, and MindMeister.

Digital Citizenship. Students must understand and practice legal and ethical behavior when using technology. If students are engaging with experts in the field, whether it be face-to-face, phone, email, Twitter, etc., they must be able to identify and know how to handle uncomfortable or unsafe situations. Preventative measures such as protecting their privacy and security are imperative, as is the assurance of teacher support if they encounter those situations.

Students must also understand the importance of protecting their private information and how to do so when accessing information online and using digital tools. The Greater Victoria School District has performed a privacy impact assessment on Google for education, hence teachers and students in Victoria can be confident using their 'sd61learn' email accounts and

logging into tools with this email. There will be many teachable moments when students can be directed to read the privacy information carefully before agreeing to the terms and conditions of apps or software.

Another important component of digital citizenship is respecting other's ownership of their digital creations. Discussions of plagiarism, copyright and license rules are important, however these can also serve as a springboard for encouraging students to copyright their own creative works (Creative Commons is a valuable resource for this).

Communication and Collaboration. Students should be encouraged to collaborate or co-construct content with peers, experts, or others using digital tools (such as Google Docs or Microsoft Word). Peer editing can be incorporated into a lesson to introduce and encourage these skills. Also, students can be encouraged to communicate through email, social media, or social networks to deepen their understanding of their inquiry topic.

Step 3: Present

Creativity and Innovation. Students should be encouraged to demonstrate their creativity and knowledge using technology, while exercising digital literacy skills. In senior science classes students can be encouraged to use digital models and simulations, identify trends and forecast possibilities, and apply or extend their knowledge to new situations.

Communication and Collaboration. Students will need to communicate information and ideas effectively using digital tools. This may include (but is not limited to) research papers, essays, slide presentations, animations or videos. Teachers can encourage students to consider their method of presentation early in the development of the inquiry project to help choose appropriate and engaging presentation methods. When choosing a software application for presenting, teachers must encourage students to consider their privacy and security when

agreeing to terms and conditions. In addition, students may choose to contribute their project knowledge to the public knowledge domain using public forums, wikis, or reviews.

Step 4: Reflect

Technology and Operations and Concepts. Through the inquiry process, students will likely have a chance to further their general computer skills and digital literacy skills. Asking students to reflect on such peripheral learning will contribute to a sense of accomplishment for the learner. Students may be able to identify that they have participated in and contributed to learning networks (i.e., Twitter), digitally collaborated and co-created with peers or teachers, or conducted effective scientific research using a variety of online resources. Teachers may choose to consult the BC Digital Literacy Framework to provide a reflective checklist of digital skills that students may have learned, used or expanded upon during the inquiry process.

It is a daunting task to tackle all the digital literacies in a single project. Choosing one or two digital literacies to focus on while instructing students how to protect their privacy while using technology can serve as a good foundations on which to build digital literacy skills.

An additional resource for developing digital literacy skills has been developed by Jarod Fong and Heidi James on their website *B.C. Digital Literacy*. This resource provides additional information on the Freedom of Information and Protection of Privacy Act (FIPPA) and B.C. policies for technology use in education, suggestions for student activities to enhance digital literacy skills, and opportunities for teachers and students to participate in an online global learning community.

Chapter 4: Reflection

Summary of Learning

My initial goal for completing my master's in educational technology was to be able to effectively and safely use collaborative technology in my Environmental Science 11 class while students were conducting inquiry projects with local experts and volunteers in the community. I had many questions about how I would coordinate and supervise communication, and how I could facilitate professional, safe interactions while being respectful of everyone's privacy and time.

That was not meant to be, as COVID 19 caused the public health orders that sent teachers and learners home right before the project was introduced. Student wellness and lightened academic workloads, together with provincial health order restrictions, caused a significant shift in my focus and lesson planning for all my classes.

It became clear very early on during my first year of classes for this master's degree just how much I did not know about using technology in education. First and foremost, FIPPA guidelines were brand new to me. I had never worried about my own privacy online, nor had I considered the implications of suggesting or using a variety of technologies in my classroom. I had never heard of the BC Digital Literacy Framework and was surprised to read how advanced the framework was suggesting our students be when it came to digital literacies. It seemed I had my work cut out for me, and it became clear that I had to start from the ground up. Building on my new knowledge of FIPPA and the BC Digital Literacy Framework and incorporating this knowledge into my project became my new focus.

Keeping this focus in mind, topics such as collaboration, personalized learning, and 'bring your own device' initiatives continued to intrigue me. I have been an advocate of students

being able to use their mobile devices in the classroom for years, and have tried to shift the mindset of my students to seeing their device as a social tool to a learning tool. Teaching students self-regulation skills, and facilitating authentic inquiry and investigation using their device is very exciting to me. This was a direction I was following for this project for some time, however the realization that some students may not have a device became a real limiting factor. That, and the fact that my focus was expanding beyond the scope of a single project, caused yet another shift for my project focus.

I felt confident that teaching digital literacy skills to enhance student engagement and learning during inquiry projects was my starting point, but could not gain much enthusiasm about my project until I was introduced to UDL. It may look simple in the format of a table infographic, however the process of analyzing and incorporating the guidelines to provide authentic, flexible, and mastery learning has proven to be a formidable task. Critical self-reflection in the application of UDL will be an on-going process if I am to meet the multitude of needs of each individual learner, however, I was thrilled to find a tool that could help me in that process.

Discovering UDL was quite timely. During the COVID 19 pandemic, more than ever before in my teaching career, I have to be flexible with how my lessons are presented and made available. Through my learning of UDL, I have become more flexible and able to respond positively and with more encouragement when I problem solve with students about all the curve-balls that have been thrown at educators this past year. Student wellness, individual and family health concerns and a condensed learning schedule are just some of the realities that require educators to be more flexible than ever, and UDL can assist with meeting those needs.

Another exciting quality of UDL is the potential for personalizing the learning and increasing student engagement. Early in our program the phrase “student voice and choice” was used and it struck me how respectful this is towards the individual and how it increased engagement. UDL promotes lesson development that is respectful of individual’s needs and interests and encourages student voice and choice at every step of the learning journey. As an added bonus, this same philosophy allows educators to meet the needs of all learners and establish an inclusive learning community. My final project question for this project was realized: How can UDL support the development of science inquiry projects while enhancing digital literacy skills?

Reflections on Growth

Learning about my own learning process has been an unexpected benefit to the program. I have never kept a journal or blogged before, and have always been intensely private on social media. Carefully organizing my thoughts for blogs and documenting my learning has been an extraordinary practice. Sharing that learning with others in my cohort and participating in educational conversations on Twitter have increased my resolve to network and engage with other stakeholders in education and are practices that will help me continue my learning long after this program is complete.

Personally, it has been challenging to tame my enthusiasm for learning and to reign myself in from the endless improvements I could make (and opportunities I could engage in) with respect to my profession. I have heard it been said, and have quoted it several times, that this profession will take everything you’ve got if you’re willing to give it. Setting boundaries for myself and narrowing my focus (so I can do a few things well rather than many things poorly)

are skills I hope to continue to develop. With the gift of time, perhaps my growing list of things to learn and interests to pursue will one day shorten…but somehow I doubt it.

I have very much enjoyed and appreciated the access to educational research and look forward to continue my investigations into effective educational practices. Thankfully, the creation of OER is gaining momentum and will allow access to the research after my student status expires which grants me access to expensive journal subscriptions. OER have now been incorporated into my teaching for inquiry and scientific research as knowledge of these resources can contribute to the goal of lifelong learning for everyone. Knowledge and appreciation of OER can also encourage students and teachers to contribute to this growing body of knowledge.

Another experience that I have valued and will carry forward is the practice of allowing students time to investigate, summarize, and present their learning with limited teacher instruction. By no means does this suggest that our professors were able to coast or slack on their planning and responsibilities, or that my own work load will lighten. It means that, with considerable planning and concise expectations, the learning can be effectively guided and facilitated through a process of inquiry, knowledge making, and self-discovery. This process is far more authentic, engaging, and meaningful than traditional stand-and-deliver methods. Although it was something I was making progress with prior to my program, experiencing this approach as a student has had a profound effect on how effectively I can facilitate this process in my own classroom. When this type of learning is coupled with respectful collaboration and communication the learning can become truly transformational.

With respect to collaborative learning, I am still wrestling with my place within the academic online community. Throughout the program, my personal views and preferred teaching practice have not always aligned with the teaching, or the popular educational thinking on my

preferred social media site, Twitter. I primarily use my Twitter account as my professional learning community and have often been challenged by the posts of educators defending a particular teaching philosophy or practice. My comfort level in engaging or contributing to these conversations is still in its infancy. My next educational pursuit is in effective communication and conflict transformation, as I look to improve these skills so I can engage in more respectful and mutually beneficial conversations online. I have been intrigued by the work of George Veletsianos since his guest appearance during our first summer of this program, and believe further investigation into his research will contribute to my development in this area.

Recommendations for Future Research, Policy Development, and Practice

This learning journey has revealed several areas that I believe would benefit from further research. There are numerous studies that focus on the benefits of employing UDL to meet the needs of students with learning disabilities, however research that considers the impact of UDL on an average student's engagement and academic performance is needed. Does UDL benefit every learner to the same extent, or is it of greater benefit to students with learning disabilities? This question could also be expanded to include gifted learners or English language learners (ELL).

A second area for suggested research is regarding the inclusion of educational technology research in the K-12 system. I understand the difficulties with this pursuit, as privacy and ethics for students under 18 is paramount. It is precisely because of this that more research needs to be done in the area of educational technology. The same reasons that prevent research in K-12 are also making the research done at the post-secondary level in educational technology not very applicable. The restrictions on technology use that exist in K-12 prevent educators from using most of the technologies available. It was very surprising to me that other districts were even

more restrictive than mine, as I believe our district's policies have significantly limited my exploration and application of many educational technologies in the past. How can one technology be trusted in one area, but not in another of the same province? How can we keep big business out when we fully endorse a single corporate platform? Can or should public education switch entirely to open sourced software? Does using technology in schools require more regulation or less? Specific areas of research in this area include investigating how educators can help build the digital literacy skills and the flexibility to navigate the plethora of technologies students may be asked to use after graduation when technology use is quite restrictive in K-12. Limiting student exposure might negatively impact or delay their development in ICT, so how can teachers most effectively protect student privacy while encouraging the exploration of various technologies? Tackling this problem will inevitably lead to policy changes, as current policy significantly restricts the technology educators can use in their classrooms. Specific policy regarding technology changes significantly from district to district, so perhaps an area for further research and development is considering the creation of provincial policy for technology use in education.

Another area I would have appreciated additional research on is how to encourage and support teacher development in educational technology in K-12. In a study titled "Predictors of fostering students' computer and information literacy" conducted in Germany, it was found that teachers' attitudes and understanding of ICT was instrumental in fostering students' ICT skills, however teacher buy-in and collaboration regarding educational technology was low (Lorenz, et al., 2019). A focus on teacher development in technology, pedagogical support, and ICT-related collaboration is imperative if educators are to help develop technologically proficient learners.

Professional development models or frameworks for district and administrative teams that reveal how such professional development might be effectively designed and maintained would be very beneficial.

When considering digital literacy and the BC Digital Literacy Framework in particular, further research into how to effectively teach specific literacies at specific grade levels would be helpful. Also, how teachers and students can utilize OER while protecting student privacy might be an interesting area of development and research in K-12 settings. It was clear during this project that taking on every digital literacy in each grade level is too big a task. Inevitably, some skills will be developed more and some less, or perhaps not at all. For example, I encountered one group of grade 11 students that did not have much experience with copyright, citations, and bibliographies. The uncertainty of what digital literacy skills students have is an area that requires further attention and prompts the following two questions: How and for what purpose are teachers currently using technology in B.C. K-12 classrooms? How can we glean information regarding current digital literacy skills of students so that we can identify and fill in some of those gaps?

Perhaps the answer to these question can be addressed through policy development more effectively than conducting further research. For example, how can our provincial curriculum further support an effective and consistent progression of digital literacy skills in K-12?

All of the aforementioned areas for future research and policy development in education will inevitably take considerable time to come to fruition. In the mean-time, I am very pleased to have acquired the skills and knowledge during this master's program to use technology and teach digital literacy skills with confidence. I have learned so much by returning to the role of student, and have appreciated the skilled instruction of my professors that have modeled the personalized

and engaging learning experience I strive to provide for my students. This experience has further fueled my love for learning, and I look forward to all the learning that is yet to come.

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Appendix A. Inquiry Project Student Handout

Examples of Astronomy Inquiry Questions

- What evidence supports the big bang theory? What evidence opposes it?
- How has the advancement of technology deepened our understanding of the universe?
- Is it possible to believe in both creation and the big bang theory?
- What ways of investigation are available in determining the age of the universe?
- How are new technologies being used to extend the reach of human investigations into space (SNOLAB, ISS, Canadarm, Dextre)?
- How has the energy in the universe changed/shifted since the big bang?
- How can we comprehend the size of our earth, the sun, our solar system, our galaxy, and the universe?
- How did scientist determine the life cycle of a star?
- How are the elements of the periodic table related to stars? Might there be additional elements that are yet undiscovered?
- How are Radio Telescopes used in exploring and understanding the universe?
- What is the likelihood of habitable planets around other stars?
- What relationships does the Herzsprung-Russell (H-R) diagram reveals and what are the importance/implications of those relationships.

Earth Science Inquiry Project

Once you find a topic of interest, how do we convert that topic into an inquiry question?

First, what *is* an inquiry question? What *is not* an inquiry question?

Simple Question	**Inquiry Question**
-Quick to answer	-Takes mental effort and time to answer
-Can be answered with a yes/no response	-Answer is found across multiple sources
-Usually one single correct answer	-No one single correct answer
-Helps to understand only the topic of concern	-Answer often leads to more questions
-Needs little or no justification	-Requires support and justifications
	-Helps to deepen understanding

Now...make your inquiry topic an inquiry question. It helps me to use the sentence starter "I wonder…"

"I wonder why…"
"I wonder what would happen if..."
"I wonder how…"

List three potential inquiry questions here:

1.

2.

3.

Planning

I like to consider how I would like to present my inquiry project first and then work backwards. This helps me set goals and develop a plan that will ultimately result in a completed project that fits my preferred method of presentation. This is not set in stone, and can change as needed, but might help in identifying how you should move forward.
Ideas for presentations include:

- Research paper
- Essay
- Model
- Video
- Tri-fold board with samples, videos or interactive components
- Information booth
- Google slides, Keynote, PowerPoint, Prezi
- Lab report
- Animation

Ideally, you can choose a method of presentation that is also in line with your interests and will help you further your communication skills. For example, if I plan on going to university and know that I will need to learn how to write research papers this is a good opportunity to practice that skill. If I want to go into business, perhaps developing a PowerPoint presentation will be useful. Or, if I am interested in animation, marketing or video production perhaps learning powtoon, Animaker, iMovie or OpenToonz are good choices. *Note: if you choose a technology that is not within the G-Suite for Education family you must pay close attention to the terms and conditions that outline how your information may be used and/or shared. Please discuss alternate technologies with the teacher.*

How will you present your Inquiry Project?

From here, I plan my time backwards.

- How long will it take once I have all my information to prepare my presentation?
- How long will it take me to convert my notes into my final draft/PowerPoint slides/animation script?
- How long will it take me to do my research?

If you have one week to do your project, perhaps giving yourself one day (3 hours) to do your presentation, 2 days (3 hours each) to convert my notes into my final draft, and 2 days (3 hours each day) to conduct my research. Your estimated timeline should leave room for setbacks and should take into account some time to practice presenting your project. Doing more work early on will minimize your stress and anxiety later. (I have always strived to complete assignments or meet my deadlines **at least** one full day in advance).

Consider your timeline/time management in the space below:

Research

You will be expected to conduct research beyond simple google searches. Two options to deepen your online search are google scholar and google advanced search.
We will also learn how to access our school's subscription to scientific journals and how to find open educational resources (examples include open access journals, online tutorials, podcasts, and online textbooks). You are encouraged to include documentaries, interviews, newspaper articles, books and other types of resources.

As you read and learn more about your topic, summarize the information in the attached handout, and consider whether it has transformed your thinking or what questions you might still have. You will see on the handout a column to keep track of your sources, which is an important habit to develop.

Synthesize

This is where you will form a conclusion from your research.

- How do my findings affect me or others interested in this inquiry question?
- What did the research evidence tell me about my inquiry question?
- What big ideas have been learned?
- How and when did my thinking change?

At the simplest level, drawing conclusions is about weighing the pros and cons of an issue. Perhaps a pros and cons chart might help you organize your thinking and form a conclusion. A strong conclusion to an inquiry question should be based on a combination of research evidence you have found, your prior knowledge and assumptions, and the connections you were able to make between the various pieces of information you studied.

Please remember, it is alright (in fact encouraged!!) to be left with unanswered questions at the end of your research. These can be included in your project conclusion, or even have a devoted slide to encourage viewers to continue learning about your topic.

Bibliography

Use the attached handout to help keep track of websites, journals, or other resources that you will include in your project or that have contributed to your understanding. Easybib is an excellent tool for creating your bibliography, as are Purdue Online Writing Lab, and the American Psychological Association website. Please use APA 7 formatting.

Create
Now you are ready to create your final presentation. Keep your audience in mind and consider how you might best engage them. You are encouraged to include graphs, images, charts, diagrams (remember, if you are using someone else's work you must include them in your bibliography).

Date	Summary	Questions, Patterns, Connections	Source

Inquiry Project Checklist

- I have determined my project topic
- I have developed my inquiry question
- I have identified my presentation format
- I have a method of recording my references (including pictures)
- I have a method of keeping notes and summarizing my learning from these references
- I have a minimum of 2 non-google search references
- I have found a website, add-on, or software that can assist me with my APA formatting for my bibliography
- I have had my peer(s) proofread my work to provide feedback
- I have had my teacher proofread my work to provide feedback
- I have incorporated feedback
- I have considered how technology can improve how I communicate my ideas
- I have considered how technology might increase my peers' engagement and interest in my project
- I have considered how pictures, props, videos and formatting might increase my peers' engagement and interest in my project/presentation
- I have considered why my project matters and how my research can be used/integrated/applied to impact others in my class/community/world.

Earth Science Inquiry Project Rubric

Category	Level 1	Level 2	Level 3	Level 4
Knowledge of Content	The student demonstrates limited knowledge of the content	The student demonstrates some knowledge of the content	The student demonstrates good knowledge of the content	The student demonstrates thorough knowledge of the content
Understanding of Content	The student shows limited understanding of the content	The student shows some understanding of the content	The student shows good understanding of the content	The student shows thorough understanding of the content
Use of Creative/Critical Thinking	The student uses creative/critical thinking processes to create final product and reflects on their learning with limited effectiveness	The student uses creative/critical thinking processes to create final product and reflects on their learning with some effectiveness	The student uses creative/critical thinking processes to create final product and reflects on their learning effectively	The student uses creative/critical thinking processes to create final product and their reflections on their learning have significant impacts and implications
Expression and Organization of Ideas and Information	The student organizes ideas and presents results of inquiry with limited effectiveness	The student organizes ideas and presents results of inquiry with some effectiveness	The student organizes ideas and presents results of inquiry effectively	The student organizes ideas and presents results of inquiry with a high degree of effectiveness
Making Connections and Applications	The student makes a limited number of connections between the project and the world outside the school	The student makes some connections between the project and the world outside the school	The student makes a variety of connections between the project and the world outside the school	The student makes a wide variety of connections between the project and the world outside the school
Presentation and Communication	The student presents their findings with others with limited effectiveness	The student presents their findings with others with some effectiveness	The student presents their findings with others effectively	The student presents their findings with others with a high degree of effectiveness
Use of Conventions, Vocabulary and Bibliography	The student's writing conventions, vocabulary, and bibliography formatting need significant improvement	The student's writing conventions, vocabulary, and bibliography formatting need improvement	The student's writing conventions, vocabulary, and bibliography formatting are good	The student's writing conventions, vocabulary, and bibliography formatting are excellent

Appendix B: Inquiry Project Check-in

Inquiry Project Check-in

At the beginning of class…

- What is your goal for class today? What are you hoping to accomplish?

- What specific steps do you plan to take today to work toward your goal?

- What will you do if you become …
  - Frustrated?
  - Distracted?
  - Overwhelmed?

At the end of class…

- Regarding my productivity today, I am particularly happy with how I…

- Regarding my productivity I can improve when it comes to …

- I still need to accomplish the following steps/things before my presentation is complete:

Today, my peer, _____, proofread/listened to/saw my presentation and provided me the following feedback:

Do you have any questions for me, or can I provide further explanations/guidance to help you with your inquiry project?

Appendix C: Inquiry Project Reflection

Inquiry Project Reflection

1. Can you identify anything that got in the way of your productivity while completing this project? Can you identify anything that was helpful to you for focusing?

2. What did you find most challenging about this assignment?

3. What did you find most rewarding or interesting about this inquiry project?

4. Did you learn any new skills during this project? Search methods? Presentation options? Citation tools?

5. What are 2 things or attributes that you noticed about your classmate's project presentations that you might want to include in your own future projects? Why did you choose these 2?

Appendix D: UDL Teacher Reflection

	What went well?	What can I improve on?
Did I provide multiple means of representation? (Guidelines 1 – 3) Were my learners resourceful and knowledgeable?		
Did I provide multiple means of action and expression? (Guidelines 4 – 6) Were my learners strategic and goal-directed?		
Did I provide multiple means of engagement? (Guidelines 7 – 9) Were my learners purposeful and motivated?		

Additional Notes: