SCIENCE TEACHERS' CULTURALLY RESPONSIVE PRACTICES IN THE CONTEXT OF DISTANCE EDUCATION: A QUALITATIVE STUDY

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ABSTRACT

Newfoundland and Labrador (NL) cultures are rooted in Ways of Knowing science among other forms of teaching and learning through Indigenous, English, Irish, and French (including other European minorities) and subsequent traditional community customs with deep ties to the ocean and the land. Schooling, which has social, cultural, and political implications, may lead to marginalization when it is enforced using standardized values and norms through prescribed science curriculum. Culturally responsive science teaching (CRST) may help build bridges between the classrooms and their surrounding communities to safeguard access to science that is accessible to all students. Practicing CRST is challenging for distance educators as remote communities merge for synchronous online learning. The purpose of this study is to explore how NL science teachers are incorporating CRST in their teaching practices by distance. The research questions include: How are distance educators making science culturally relevant for students regarding their rural homelands and community cultural identities? What challenges do distance science educators face with implementing CRST in the virtual classroom? A grounded theory approach was used to support a growing framework for CRST in the context of distance education resulting in three components: challenges (constraints due to lack of physicality, curriculum, and pedagogy), affordances (a respectful, and safe environment for students online), and applications (inclusion of culturally relevant science projects, and subject matter).

Keywords: culturally responsive science teaching (CRST), distance education, rural education, cultural identities, ways of knowing science, culturally relevant project-based learning (CRPBL), culturally relevant subject matter (CRSM).

General Summary

Newfoundland and Labrador (NL) cultures are rooted in Ways of Knowing science with ties to various heritages. Schooling may lead to marginalization when it is enforced using standardized values and norms. Culturally responsive science teaching (CRST) may build bridges between classrooms and communities by respecting and including students' cultures in science. Practicing CRST can be challenging for distance educators as their online students are from diverse, remote communities. The purpose of this study is to explore how NL science teachers are incorporating CRST in their teaching practices by distance. The research questions include: How are distance educators making science culturally relevant for students regarding their rural homelands and community cultural identities? What challenges do distance science educators face with implementing CRST in the virtual classroom? Interviews with NL distance science teachers were used to gather data to support a model for CRST. Results included challenges, affordances, and applications of CRST.

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Chapter 1: Introduction

Education is active in shaping culture through schooling—the process of being formally educated in a school (Davis et al., 2015). Schooling has social, emotional, and psychological implications on students, in addition to cultural, political, and historical implications on their communities, and lifestyles. Due to these implications, it is inconceivable to enforce standardized values and norms without marginalization (Roberts, 2017). In the context of K-12 education, students bring with them their community cultures and literacy practices, however, they are not always recognized or acknowledged in a standardized curriculum which may lead to misframing who students are and how they are represented in the classroom, and henceforth, society (Madondo, 2021). With a focus on equity, diversity, inclusion, and social justice in the context of education, solutions have been acclaimed to contest the ongoing hegemonic school structures that may promote or impose certain values and norms on non-dominant groups; among these solutions are the framework and principles of Culturally Responsive Teaching (CRT).

Education theorist Gloria Ladson-Billings defines CRT as "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (1994, p. 17). According to Gay (2002), the idea of CRT is "based on the assumption that when academic knowledge and skills are situated within the lived experiences and frames of reference of students, they are more personally meaningful, have higher interest appeal, and are learned more easily and thoroughly" (p. 106). In the context of science education, Culturally Responsive Science Teaching (CRST) may safeguard access to science with the inclusion of diverse Ways of Knowing by joining Western styles of teaching and learning with rurality and cultural identities. CRST surfaced with thematic frameworks, although there are no published frameworks that support the unique classroom environments and challenges of distance education—that which is growing in popularity and demand.

1.1 Study Context and Purpose Statement

Newfoundland and Labrador (NL) is Canada's most Eastern province bounded by the Atlantic Ocean, encompassing freshwater and boreal forests with many natural resources (i.e., fisheries, aquaculture, forestry, agriculture, and agri-foods) (*Fisheries, Forestry, and Agriculture,* n.d.). These resources provide for much of the NL economy and its inhabitants across 560 individual communities and 275 Municipalities and Inuit Community Governments; of these 560 communities, over 500 have populations less than 1,000 (Hood, 2022). NL cultures are rooted in Ways of Knowing science among other forms of teaching and learning through Indigenous, English, Irish, and French (including other European minorities) and subsequent traditional community customs with deep ties to the ocean and the land..

The practice of CRST is particularly challenging for distance educators. The geographical nature of the province and the population sizes of its' many small communities make it challenging for the province to cater to academic needs of all students from rural communities. Therefore, virtual schooling was instated in NL out of necessity to cope with the issues of a decreasing population and a large geographical area (Mulcahy et al., 2016; Saqlain, 2016). Mulcahy et al., (2016) noted the Government of Newfoundland and Labrador's Task Force final report, *Improving the Quality of Education: Challenge and Opportunity* (Crocker & Riggs, 1979) recognized "inequity in educational opportunities in the province's rural communities" where many rural schools did not have the capacity to offer courses including sciences for students due to lacking "requisite student population or the teacher expertise" limiting their potential to be successful in postsecondary education and careers (p. 28). To address this inequality and challenge in NL rural education, the province began a distance education program in 1988 "to provide access to secondary level courses that were important for post-secondary admission" for small rural schools in NL (Mulcahy et al., 2016). This led to offering the first distance education course for 36 students from 13 small rural schools through the Telemedicine and Educational Technology Resources Agency (TETRA). TETRA provided multiple opportunities for rural high school students to complete courses in mathematics, chemistry, and physics within 15 years of their operation (Barbour, 2005; Saqlain, 2016).

The vision for distance education in NL was to provide access to a standardized curriculum approved for the province "as a means of equalizing educational opportunity" for high school students. The 1999 Sparks-Williams Ministerial Panel on Educational Delivery identified issues related to distance education delivery in NL, especially the "synchronous component" and students' independent learning (Sparkes & Williams, 2000, p. 65) and made many recommendations to adopt new technologies. As a result of the Sparks-William panel, distance education in the province of NL turned into a web-based virtual schooling system in 2001 through the development of the Centre for Distance Learning and Innovation (CDLI). The purpose of CDLI was "to provide rural students with the same spectrum of programs and course opportunities as urban students" (Mulcahy et al., 2016., p.28) through virtual learning by Electronic Teachers (E teachers) and classroom teachers as mediators between rural schools and E teachers (Barbour, 2005; Mulcahy et al., 2016; Saqlain, 2016). For more than two decades, CDLI has been providing access to science courses to high school students from small rural communities. Despite claiming that equalizing educational opportunity was the focus of distance/virtual education in NL, the discussion did not further to the unique characteristics of rural communities and students and how to make virtual education more relevant for these learners (Barbour, 2005; Mulcahy et al., 2016; Saqlain, 2016).

The 2017 report of the *Premier's Task Force on Improving Educational Outcomes, Now Is the Time*, was silent on rural and/or distance education in NL; however, many recommendations were made by the task force to the government for the development of inclusive, Indigenous and Multicultural education. The section on Indigenous education made a few relevant connections to rural education through their proposed adoption of Indigenous Ways of Knowing. According to the Office of Indigenous Initiatives at Queen's University (2024),

> Indigenous Ways of Knowing are incredibly sophisticated and complex. These Ways relate to specific ecology in countless locations, so the practices, languages and protocols of one Indigenous community may look very different from another. Yet, Indigenous Ways of Knowing are commonly steeped in a deep respect for the land, and the necessity of a reciprocal relationship with the land.

Also, the 2017 report highlighted that when teachers are from Indigenous communities, students benefit through better enrollment and achievement (Collins et al., 2017). Similarly, the section on Multicultural Education addressed the issue of student diversity and the presence of various cultures in K-12 schools in NL due to the increased number of newcomer and refugee students. However, the reference to culture remained limited to newcomers and refugee students. As described above, the province of NL consists of various small rural communities and high school students from these rural communities bring various Newfoundland cultures that are rooted in Ways of Knowing science among other forms of teaching and learning through Indigenous, English, Irish, and French (including other European minorities) and subsequent traditional community customs with deep ties to the ocean and the land. Therefore, rurality and culture are at the forefront of many rural education programs, particularly distance education in NL, that aim to provide equal access and opportunities to rural high school students. Although, the very principles that distance education is founded on (access to dominant knowledge to achieve equity) may, in fact, be a social justice issue: an issue where curriculum does not engage with rural culture and diverse Ways of Knowing. CRT may address the above issue of access and equity, where CRST may safeguard access to science with the inclusion of diverse Ways of Knowing and opportunities by joining Western methods of teaching and learning with rurality and cultural identities. However, how CRST can be implemented in the context of distance education and virtual schooling in NL is unknown.

Distance science educators in NL are providing education to secondary students from communities where rurality and culture are at the forefront to many of their families' livelihoods. The purpose of this study is to explore how NL science teachers are incorporating CRST in their teaching practices by distance. The conceptualization and design for this research is guided by the questions:

(i) How are distance educators making science culturally relevant for students regarding their rural homelands and community cultural identities?

(ii) What challenges do distance science educators face when implementing CRT in the virtual classroom?

1.2 Research Gap and Overview of Methodology

Few studies have been conducted on rural NL education (Barr, 1995; Goodnough & Galway, 2019; Mulcahy et al., 2016; Murphy, 2010; Saqlain, 2016), with a knowledge gap in the research of distance education in NL pertaining to recognizing rurality and cultural identity with respect to teaching and learning science by distance. This study aims to explore distance science educators' experiences with CRST using qualitative methodology to support a growing framework for CRST. This qualitative research study used a grounded theory approach to deduce a theoretical framework for CRST from data collected by semi-structured interviews. Grounded theory, as defined by Creswell (2014) is "a qualitative strategy in which the researcher derives a general, abstract theory of a process, action, or interaction grounded in the views of participants in a study" (p. 292). The grounded theory approach to this study followed the steps outlined by Corbin and Strauss (2007), which involved generating categories of information and deducing a theory from the interconnection of the generated categories.

1.3 Personal Aspirations for the Research

My aspirations for this study stem from (i) my experiences growing up in rural NL, (ii) my connection to the people of this province, the culture, and the land, (iii) my experiences of learning in rural and urban science classrooms in NL, and (iv) my practice in teaching science in rural and urban NL, as well as by distance (CDLI). I envision rural recognition and cultural relevancy (including NL students' voices, worldviews, home-based experiences, and practices) to be reflected through the construction of knowledge, through the implementation of CRT in science education. I acknowledge that implementing CRT through distance is a challenge, adding further complication for distance educators who are trying to make science accessible to all their learners from rural communities across NL. I believe CRST practices within distance learning can remove geographical barriers by making science relevant to rural and Indigenous Ways of Knowing and living. CRST may also feature equitable science teaching and learning environments for diverse rural learners. The next chapter will review the literature pertinent to the research.

1.4 Organization of the Thesis

The thesis is organized into five chapters and five appendices. Chapter One (Introduction) provides an overview of the research study, establishes the background for the research, describes the reasons for choosing the topic for this research, outlines the research questions, and discusses the worthiness and value of this research study.

Chapter Two (Review of the Literature) presents a synthesis of the relevant literature that supports the rationale and significance of the current study. The topics reviewed include framing science with rurality and culture, Culturally Responsive Teaching (CRT), suggested frameworks of CRT, Democratic Citizenship Education (DCE), Culturally Responsive Science Teaching (CRST), and the challenges of implementing CRT/CRST and online education. The chapter concludes with a brief history of Newfoundland and Labrador regarding its' heritage and culture, the progression of rural schools and distance education, as well as the development of the province's science curriculum leading to the identification of a gap in the research.

Chapter Three (Methodology) describes the research process, presenting the design of the research study and the qualitative research methodology as a research approach. It describes the research participants, data collection, interview tools used to encourage teachers to tell their stories to gather information, and the process of data analysis.

Chapter Four (Findings) is organized into three parts. Part One includes the participants' interview responses organized into conceptualizations and sources of CRST knowledge. Part Two includes their shared examples of CRST practice. Part Three includes the participants' discussions on the challenges with implementing CRST.

Chapter Five (Discussion, Conclusion, and Implications) discusses the findings with relevance to the published frameworks mentioned in the literature review. This chapter is organized by the distance science educators' interpretations of CRST, their practices of CRST, the challenges with implementing CRST by distance, and the development of a CRST framework for distance science education. The chapter concludes with the implications for science education and future research.

Chapter 2: Review of the Literature

This chapter begins with a restatement of the research problem followed by an overview of the literature pertinent to the problem, and the context for the research. Section 2.2, "Framing Science with Culture," begins with a description of CRT, followed by a description of its relation to DCE The section proceeds to explain CRST in the context of rurality, culture, and recognizing rurality in science education. The section is completed with a discussion of the current challenges for the inclusion of CRT and CRST in the physical classroom, and challenges with teaching in the online setting. Section 2.3 begins with a brief history of NL regarding heritage and culture followed by a description of NL rural schools and NL's distance education program. The section continues by describing components of the Government of Newfoundland and Labrador's Department of Education science curriculum guides, including descriptions of the General Curriculum Outcomes (GCOs), Context for Teaching and Learning, Inclusive Education, Differentiated Instruction, as well as their definition of Science, Scientific literacy, and Scientific Knowledge. The chapter concludes with a discussion of the gap in the research.

2.1 Restatement of the Problem

NL is Canada's most Eastern province, bounded by the Atlantic Ocean. The province has 560 individual communities with 275 Municipalities and Inuit Community Governments; of these 560 communities, over 500 have populations less than 1,000 inhabitants isolated along both coastal and inland regions of the province (Hood, 2022). The geographical nature of the province and the population sizes of its' many small communities make it challenging for the province to cater to the academic needs of all students from rural communities. Therefore, virtual schooling was instated in NL out of necessity to cope with the issues of a decreasing population and a large geographical area (Saqlain, 2016). The vision was clear: to provide access to a standardized curriculum, approved for the Province of NL following the recommendations of the 1999 Sparks-Williams Ministerial Panel on Educational Delivery, where learners can take online courses as rural schools are limited in resources and qualified teachers (Saqlain, 2016). Although the very redistributive principles on which distance education is founded (access to dominant knowledge to achieve equity) may in fact be a social justice issue: an issue where curriculum does not engage with rural culture and the diverse Ways of Knowing.

Distance science educators in NL provide education to secondary students from communities where rurality and culture are at the forefront of many of their families' livelihoods. The purpose of this study is to explore how NL science teachers are incorporating CRST in their teaching practices by distance. The conceptualization and design for this research is guided by the following questions:

(i) How are distance educators making science culturally relevant for students regarding their rural homelands and community cultural identities?

(ii) What challenges do distance science educators face when implementing CRT in the virtual classroom?

2.2 Framing Science with Rurality and Culture

A well-composed description of rurality was suggested by Chigbu (2013) as "a condition of place-based homeliness shared by people with common ancestry or heritage and who inhabit traditional, culturally defined areas or places statutorily recognized to be rural" (p. 815). A significant facet of rurality, culture, has been defined many times since its' timeless definition provided by the 19th-century English anthropologist Edward Burnett Tylor, "Culture…is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by [individuals] as a member of society" (Tylor, 2010) with first publication in *Primitive Culture* (1871). Rurality and culture are intertwined and rooted in isolated communities where unique traditions and customs are preserved. Rural and cultural identities are important guiding principles in CRST. Diversity should be recognized when teaching students of various rural and cultural backgrounds and used as a strength in CRST (Azama & Goodnough, 2018). According to Azam and Goodnough (2018), “Value and respect for diversity [is used to] help students feel respected, achieve a sense of belonging, and contribute to relationships that foster communities of learning” (p. 85). Azam and Goodnough proceed to explain how respect and value can be achieved for a particular culture, by, for example, “using words from other linguistic backgrounds in the classroom, using specific cultural practices such as talking circles to replace group discussions, and acknowledging established principles and respecting cultural values and traditions” (p. 85).

To ensure cultural preservation by enacting CRST in teaching science by distance, Avery and Haines (2017) suggest three methods of recognizing rurality in science education (all of which may be adopted in the virtual classroom):

(1) connecting science education to students’ sense of ‘place’ as physical, historical, and sociocultural dimensions in their community,

(2) applying students’ ‘funds of knowledge’ and cultural practices, and

(3) using project-based science learning centered on authentic questions and activities that matter to students’ (p. 162)

Barron et al. (2021) described “Funds of Knowledge” as “the skills and practices that are local to an individual's household or community and have accumulated over time” (p. 1325) with reference to works by Llopart and Esteban-Guitart (2018) and Rodriguez (2013).

2.2.1 Defining Culturally Responsive Teaching and Suggested Frameworks

The foundational work for Culturally Responsive Teaching (CRT) was established by Gloria Ladson-Billings and Geneva Gay. Education theorist Gloria Ladson-Billings defined CRT as "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (1994, p. 17). Researcher, author, and professor of multicultural education and curriculum theory, Geneva Gay, describes the practice of CRT as "using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively" (2002, p. 106). According to Gay (2002), the idea of CRT is "based on the assumption that when academic knowledge and skills are situated within the lived experiences and frames of reference of students, they are more personally meaningful, have higher interest appeal, and are learned more easily and thoroughly" (p. 106). Another definition of CRT was proposed by senior writer and editor in the National Education Association, Cynthia Kopkowski. Kopkowski describes CRT as:

> Understanding students' home life, their language, music, dress, behavior, jokes, ideas about success, the role of religion and community in their lives, and more. It is bringing the experiences of their 24-hour-day into the seven-hour school day to give them information in a familiar context. (2006, p. 1)

Many scholars have conceptualized CRT in the context of K-12 classrooms and suggested frameworks. Ladson-Billings (1995) developed a framework for CRT for use in classroom settings involving three pillars: (i) academic success, (ii) cultural competence, and (iii) critical consciousness. Within this proposed framework, *academic success* focuses on providing students with multiple opportunities to practice and demonstrate their learning of key skills and knowledge (Ladson-Billings, 1995). Cultural competence is explained by Ladson-Billings (1995) as the teachers' skills to affirm and appreciate students' cultures and to communicate across differences, to use a critical race lens when analyzing a historical moment, and to support real world solutions. The third pillar of CRT, critical consciousness (or sociopolitical consciousness), is defined by teachers' ability to engage students in challenging the status quo of the current social order (Ladson-Billings, 1995), in other words, to provide students the skills required to improve the current system of social structures and institutions through cultural acknowledgement, representation, and appreciation (e.g., inclusion of Indigenous Knowledge Systems in the science classroom). Teachers engaging in CRT must uphold these pillars as key elements of their students' learning experiences. Ann Haley Mackenzie, author of "Why culturally relevant science teaching is vital in our classrooms" (2021) suggests the application of Ladson-Billings' CRT framework by using students' prior experiences and frames of reference, in addition to embracing culture, history, and storytelling in teaching. According to Mackenzie (2021), students and teachers must engage in deep conversation, exploration, and investigation if critical consciousness is desired. Recognizing and appreciating the engraved values of students represents the pathway to critical consciousness where teaching and learning are not separate from social justice and democracy—fundamental concepts to the principal theory of DCE (Davis et al., 2015).

Like CRT, (trans-multi)culturally responsive education was proposed to "unravel the inequities that are embedded in everyday modes of schooling" (Raisinghani, 2019, p. 27). Raisinghani (2019) claims that "culturally diverse students feel uprooted and unwanted, as their cultural Ways of Knowing remain unacknowledged and their voices unheard in many Canadian classrooms" (p. 27). Raisinghani (2019) urges teachers to become (trans-multi)culturally responsive through:

(i) Embracing comprehensive understandings of culture and cultural diversity and acknowledging our identity as (trans-multi)cultural human beings

(ii) Educating the whole child intellectually, emotionally, socially, and politically by building a community of learners through utilizing the 6Cs: choice, collaboration, communication, critical thinking, creativity, and care; and

(iii) Engaging in critical self-reflective inquiries and complicated conversations to co-construct (trans-multi) responsive curricula.

(Trans-multi)culturally responsive education shares many facets with CRT as proposed by Ladson-billings (1995), including the importance of understanding culture and cultural diversity (compared to cultural competence), utilizing the 6Cs (compared to providing students with multiple opportunities to practice and demonstrate learning), and critical self-reflective inquiries (compared to critical consciousness).

2.2.2 Culturally Responsive Teaching and Democratic Citizenship Education

Education systems mirror society as societal norms and values are woven into community and schooling. CRT can be difficult to envision within a standardized education model where "curriculum sees the nation as one, and all students, and all places, as having the same needs in terms of knowledge" (Roberts, 2017, p. 15). Norms in standardized education continue to be justified by underlying antiquated values that sustain the marginalization of specific groups of people and therefore, DCE is a necessary amendment to the standardized education system (Davis et al., 2015). Public school teachers must become aware of the engraved values within the hidden curriculum to recognize and appreciate the differing beliefs, ideologies, and values that coexist in a classroom. The hidden curriculum constitutes the norms, values, and beliefs that are implicitly taught through curriculum foci, classroom resources, institutional structures, grading practices, and teaching methods (Davis et al., 2015). Students' voices, worldviews, cultures, and the literacy practices are not always acknowledged or recognized in schools, which may lead to misframing science in classrooms. Misframing science education within the domains of structure and culture could be seen as a form of social injustice, particularly in rural geographical locations that may "negate local knowledge that might nevertheless be relevant in science classrooms" (Madondo, 2021, p. 33). Science curriculums should reflect students' voices as their worldviews, home-based experiences, and practices are important in the construction of knowledge or their Coming to Know. The concept of "Coming to Know" is a term used to describe the process of knowledge acquisition or understanding in Indigenous Science (Cajete, 2000; Colorado, 1988; Peat, 1994).

The view of DCE includes (a) participation and (b) conscientization, which may assist teachers in the creation of social values within K-12 classrooms (Davis et al., 2015). Participation is not meant to impose a particular "social value", rather, it is meant to put focus on how minds are cultured, that is, "how one's identity is shaped and how one participates in shaping others' identities through participation in knowledge systems" (Davis et al., 2015, p. 135). Conscientization emphasizes how culture should be recognized through enabling and motivating informed action against oppression by becoming aware of social and political contradictions (Davis et al., 2015).

A school's atmosphere is a vibrant part of the commonwealth and vital in fostering a democratic citizenship model by respecting all members of the school community. Without a change in value, there will be no change in norm, and hence no change in school structure to reflect democratic citizenship. To embrace DCE, inclusion of cultural identity to prevent rural marginalization is essential (Roberts, 2017). Inclusion of cultural identity in education requires "a knowledgeable teacher, a supportive administrator, the appropriate resources, a collaborative faculty, and adequate time...[and] to look outside of the school to take into account the ways national-, state [or province]- or district-level standards and standardized assessments constrain science education reform" (Carlone et al., 2010, p. 474). Ultimately, CRT can be visualized in the framework of DCE by bridging classrooms and communities (Mackenzie, 2021).

2.2.3 Culturally Responsive Science Teaching

Studies in Culturally Responsive Science Teaching (CRST) surfaced with thematic frameworks pointing to the importance of CRT in the context of science education. Cooper and Matthews (2005) describe the inclusion of cultural relevancy in teaching science as essential to students' science education. Cooper and Matthews claimed,

> Science teachers must become acquainted with their students, especially within the communities in which they live. By doing so, science becomes a contextualized engagement and a culturally relevant experience, one that allows students to link their daily experiences to what they do in class." (2005, p. 52)

This section will review three published conceptual frameworks on CRST, namely those by Barron, Brown, and Cotner (2021); Hernandez, Morales, and Shroyer (2013); and Stephens (2000). Barron et al. (2021), describe CRST as a powerful pedagogical tool that incorporates student interaction, differentiated instruction, intentional scaffolding, relevancy to students' lives, and the reduction of student anxiety, by attempting to "decolonize classrooms such that students and community members exercise sovereignty, self-determination, and cultural and linguistic repossession" (p. 1323). The outlined themes of CRST by Barron et al. (2021) include:

(i) student interaction, (ii) differentiated instruction, (iii) intentional scaffolds, (iv) relevancy to students' lives, and the (v) reduction of student anxiety. According to Barron et al. (2021) student interaction is represented by ensuring that students have the opportunity to talk and work amongst themselves in solving difficult problems together; differentiated instruction happens when teachers who intentionally change their approach to better serve their students (to improve their self-efficacy and learning); intentional scaffolds are used by teachers when building confidence in science understanding and encouraging student agency in science learning; relevancy to students' lives occurs when linking science content to students' skills, talents, and household knowledge and practices gained from within their homes and communities; and the reduction of student anxiety is represented by creating safe spaces for students to be themselves.

The framework of CRST proposed by Hernandez et al. (2013) includes: (i) content integration, (ii) facilitating knowledge construction, (iii) prejudice reduction, (iv) social justice, and (v) academic development. Content integration is defined by Hernandez et al. (2013) as the inclusion of content from other cultures, the fostering of positive teacher-student relationships, and holding high expectations; the theme facilitating knowledge*,* is defined as building on what the students know using "real world" examples and assisting students in learning to be critical, independent thinkers who are open to other Ways of Knowing; prejudice reduction is defined by the use of native language support, positive student-centered interactions, and a safe learning environment; social justice describes the teacher's willingness to act as agents of change, and the encouragement of question-posing and challenging the status quo in order to aid in the development of sociopolitical or critical consciousness accomplished through modeling; and academic development represents the teacher's ability to create opportunities to aid all students in their development as learners to achieve academic success, and the use of research-based instructional strategies that reflect the needs of students of diverse backgrounds.

The studies by Barron et al. (2021) and Hernandez et al. (2013) share many similarities among their CRST frameworks (e.g., intentional scaffolds and facilitating knowledge construction, relevancy to students' lives and content integration, etc.). In addition to these proposed frameworks, the "Handbook for Culturally Responsive Science Curriculum" by Stephens (2000) describes CRST by generalizing the culturally responsive science curricula into four categories: cultural relevance, standards based, best practices, and assessment. Within these categories, Stephens (2000) describes the culturally responsive science curricula as having the following factors of importance:

> [i] cultural significance, involving local experts, [ii] linking science instruction to locally identified topics and to science standards, providing ample opportunity for students to develop a deeper understanding of culturally significant knowledge linked to science; [iii] teaching practices that are compatible with the cultural context; and [iv] engaging ongoing authentic assessment, guiding instruction with deeper cultural and scientific understanding, and reasoning and skill development tied to standards. (p. 7)

The handbook describes the integration of traditional Indigenous knowledge and western science, with emphasis on a common ground between the two: organizing principles (e.g., body of knowledge is stable but subject to change), habits of mind (e.g., honesty, inquisitiveness), skills and procedures (e.g., empirical observation in natural settings), and knowledge (e.g., plant and animal behaviour, cycles, habitat needs, interdependence). Stephens (2000) claims "the work of creating a culturally responsive science curriculum is context specific, dynamic and ultimately reflective of what one believes, values and thinks worth knowing" (p. 10). The application of knowledge is of paramount importance and should be the forefront of topic selection, with the local environment and seasonal appropriateness in mind (Stephens, 2000).

2.2.5 Challenges with Implementing CRT and Teaching Online

Challenges with implementing CRT within the context of instructional designers' cultural responsiveness were discussed by Rogers et al. (2007) and included three barriers:

> "(i) an overemphasis on content development as the center of practice and under-emphasis on context and learner experience, (ii) a relative lack of evaluation in real-world practice, and (iii) the creation of less-than-ideal roles that instructional designers assume in the larger organizational structures involved." (p. 207)

In addition to the challenges outlined by Rogers et al. (2007), Belgarde et al. (2002) discussed cognitive load as a challenge for teachers when incorporating CRT in their teaching practices as it includes the increased burden or effort for knowledge transfer with limitations on available resources. Other challenges found within the literature included: teacher uncertainty on drawing on students' funds of knowledge (Rodriguez, 2013), and limited autonomy in curriculum design/implementation (Barron et al., 2021).

In addition to the challenges of implementing CRT, specific challenges with teaching online (using the internet as a platform to educate) were found (e.g., Artze-Vega & Delgado, 2019; Nilson & Goodson, 2018) including educators' "familiarity with/preference for face-to-face teaching; their limited technological abilities and busy schedules; the relative absence of experienced online faculty to serve as opinion leaders and role models; and [educators'] attitudinal beliefs about technologies" (Artze-Vega & Delgado, 2019, p. 27). Nilson and Goodson (2018) identified challenges with teaching online with a focus on disincentives: (i) lack of institutional support and rewards, (ii) unreliable technology, (iii) absent or poor technical support, (iv) absent or inadequate training, (v) concerns about workload, and (vi) concerns regarding quality. According to Nilson and Goodson (2018) these disincentives manifest as disengagement and/or resistance to online teaching and related professional development. Ambrose et al. (2010) identified three challenges with implementing CRT online: (i) perception of value, (ii) self-efficacy, and (iii) a supportive environment. According to Ambrose et al. (2010), many teachers did not recognize the value of CRT and struggled with self-efficacy in terms of implementing CRT, largely due to a lack of a supportive environment (insufficient faculty supports).

Artze-Vega and Delgado (2019) proposed ways to overcome challenges with implementing CRT in distance education by encouraging influential developers (e.g., administrators or curriculum developers) to "help [educators] see the purpose and value of online learning, culturally responsive teaching, and culturally responsive online teaching" (p. 30). Artze-Vega and Delgado also suggested the developers "help [educators] gain confidence in their technological skills, and in their ability to teach online and in culturally responsive ways" (p. 30) as well as "exhibit the same care and cultural responsiveness [that] [educators] are encouraged to employ in their teaching, making it safe for [educators] to make mistakes and promoting collaboration among [them]" (p. 30).

2.3 The Newfoundland and Labrador Context

Poet, author, and civil rights activist, Maya Angelou once said "You can't really know where you're going until you know where you have been" which is a great way to describe why we must first consider the history of NL, its geography, population, and culture, prior to discussing barriers to secondary education in NL. We need to understand how and why distance education has emerged before we can determine where it can take us. Students' school environments and living environments can appear very different from one another, separating what and how students learn in school from their lived experiences. This section will be organized in the following categories: (1) A Brief History of NL Heritage and Culture, (2) NL Rural Schools and the Emergence of Distance Education, (3) The NL Science Curriculum, and (4) the Research Gap.

2.3.1 A Brief History: NL Heritage, and Culture

NL is Canada's most Eastern province, bounded by the Atlantic Ocean, encompassing freshwater and boreal forests with many natural resources that provide for the economy of the province and its' inhabitants (i.e., fisheries, aquaculture, forestry, agriculture, and agri-foods) (*Fisheries, Forestry, and Agriculture*, 2021). NL has 560 individual communities with 275 Municipalities and Inuit Community Governments; of these 560 communities, over 500 have populations less than 1,000 (Hood, 2022). NL became rich with heritage and culture as traditions, customs, and Ways of Knowing were passed down and continue to be passed down through generations among Indigenous peoples, and various settlers (demonstrated through music, food, art, clothing, etc.).

Indigenous groups are estimated to have lived on the land for several thousands of years (Hood, 2022). According to the government website *Heritage Newfoundland and Labrador* written by Pastore (1997) from the Department of Archaeology and Department of History at Memorial University of Newfoundland, NL is home to four peoples of Indigenous ancestry: the Innu, the Inuit, the Southern Inuit of NunatuKavut, and the Mi'kmaq (Pastore, 1997). There are two Innu groups from the Innu Nation: The Sheshatshiu Innu who live primarily in the community of Sheshatshiu, while the Mushuau Innu live in Natuashish (coastal Labrador) (Goodnough & Galway, 2019; Pastore, 1997). The Innu are represented by the Innu Nation

(Pastore, 1997). The Southern Inuit of NunatuKavut (represented by the NunatuKavut Community Council) are claimed to be the descendants of Inuit women and European fisherman (Goodnough & Galway, 2019; Pastore, 1997). Conne River, Bay d'Espoir (on the island's south coast) comprises the largest community of the Miawpukek Mi'kmaq First Nation (represented by the Miawpukek Band Council), the only federally recognized reserve on the island portion of the province) (Goodnough & Galway, 2019; Pastore, 1997). Other people of Mi'kmaq decent primarily live in central and western Newfoundland and are represented by the Federation of Newfoundland Indians (Pastore, 1997). Following the death of Shawnadithit in 1829 (widely believed to be the last known Beothuk), the Beothuk were perceived to be an extinct group of Indigenous people largely due to the British invasion, although new evidence suggests Beothuk DNA persists in genome lineages among Indigenous peoples today (Carr, 2020).

Settlers of NL included: Basques, Portuguese, Spanish, British, Irish, and French arriving as early at the 16th century (Hood, 2022). European settlers fought amongst themselves for claim to the land (primarily between the English and the French), ultimately resulting in British sovereignty which governed Newfoundland until 1949 when Newfoundland joined Labrador in the Canadian Confederation. British invasion of Newfoundland caused violent conflict with the provocation of disease and injury among Indigenous groups resulting in the death of thousands of Indigenous peoples across the land (Hood, 2022).

A vast array of cultures grew from the multitude of Indigenous communities and small settlements across the province. Colonialism, economic exploitation, and religious and spiritual intolerance in NL caused a division among the people in early multiculturalism leading to stunted educational developments (Goodnough & Galway, 2019; Rowe, 1964). Educational reform in Canada in the past few decades had included the dismantling of the denominational school systems (schools of religious denomination), and the movement away from a standardized/factory model of schooling (which was primarily focused on educating using a teacher-centered, common, single approach). (Davis et al., 2015). The reform led to the authentic education movement (student-centered), with the inclusion of DCE initiatives (Davis et al., 2015). According to Sarid (2014),

> Authentic education aims to encourage the personal development of individuals to shape their own identity according to their own interests, preferences, and capabilities as well as to express their own unique and irreplaceable individuality within learning processes (p. 474).

NL is rich in culture as the diversity in customs, traditions, and Ways of Knowing remain strong with its people; rurality and cultural identity continue to be of importance to the livelihood of NL. Many communities have remained isolated despite globalization, with cultural preservation. The next section will review rural schools and the development of distance education.

2.3.2 NL Rural Schools and Distance Education

In NL, a rural school is one that is in a rural area (a community with <5000 inhabitants) (Barr, 1995). Many NL rural schools are in isolated areas of the province, accessible only by ferry or small plane (Barr, 1995). Distance education is the implementation and delivery of education through means (i.e., internet, radio, etc.) that can accommodate students not being physically present in the same environment as their educator (and sometimes, other classmates), enabling students the freedom to learn despite their geographical boundaries (Barr, 1995). Distance education has become popular since the dawn of the internet as online learning uses technology with web-based tools for instruction, research, and communication. Research and development in teaching and learning online is dominated by the adult education sector, leaving studies pertaining to K-12 distance education limited. In recent years, K-12 schools around the world were forced to partake in remote education (defined by the transition from in-person to online learning without disruption, where in-person instruction is halted or prevented, e.g., the COVID-19 pandemic). Although remote childhood education is novel, distance education had been in existence for children residing in rural areas of NL prior to the COVID-19 pandemic. Distance education was first introduced to NL in 1988 with the offering of advanced mathematics courses (Barr, 1995); since, it has grown to offer secondary courses from all disciplines. Since 2001, the Government of NL instated a new division of the Newfoundland and Labrador English Schools District (NLESD): The Center for Distance Learning and Innovation (CDLI). The NLESD became "NL Schools" in 2023 during this research process and henceforth the public school sector in NL in this study will be classified as NL Schools.

Distance education classes at the CDLI are synchronous and utilize the Zoom software for teacher instruction (instructor is usually on camera and/or sharing their screen for lectures, presentations, and demonstrations). Students have the choice to remain off camera and their microphones are usually turned off to minimize background noise (students can still be called upon to answer questions, but many prefer to use the text box feature). Students are equipped with a school-provided computer on campus for their classes (in a separate technology room, or spare classroom to utilize), they have the choice to login from home if they are physically not attending their community school that day. The CDLI teachers take attendance for their distance education classes online. Class sizes vary depending on the availability of teachers for a course, number of high school students in a particular community offering CDLI courses, student interest, etc. and can change significantly from year to year (some classes can have 1-2 students, others may have >25 students). All intangible course materials (lectures, practice quizzes, etc.)

are uploaded and accessible to the students from an online platform called Brightspace. Gathering all tangible resources (e.g., laboratory supplies) must be requested and organized by the CDLI teachers to be sent to the schools (laboratories are usually monitored by a staff member from the community school—although they [the laboratory supervisors] are not required to know details of the lab—they are only required to be present to help students with equipment handling and safety. At times, a delegate from the CDLI may travel to complete science laboratories with students across the province at different times of the year. Paper and pencil tests are printed and completed at the students' community schools with a proctor (principal, assistant principal, or teacher from that school).

In-person teaching is limited for rural science students as qualified science teachers remain difficult to recruit to remote areas of the province (many NL Schools teaching positions remain unfilled compared to positions in urban areas). Although the CDLI became a resource by providing "equitable access to educational opportunities in a manner that renders distance transparent" (CDLI, 2022), rural secondary schools remain confronted with unique challenges in learning. From my own experiences teaching by distance, online learning is not exceedingly student- or community- centered, action-oriented, and culturally relevant, rather, it favours a standardized, teacher-centered model of instruction. As students merge from diverse, rural communities for online learning, students' voices may be shadowed leaving science an irrelevant experience to their rural livelihoods and community Ways of Knowing. Challenges with getting to know students—integral part of CRT—may be much greater by distance as students appear to be less inclined to share about themselves in the virtual classroom or with a teacher by distance. In terms of the curriculum, the NL Schools science curriculum favours in-person teaching and learning through its' emphasis on in-person instructional practices (i.e., easier access to hands-on activities such as science laboratory exercises, field trips, and other collaborative in-person activities and projects). The next section will highlight the NL Schools science curriculum framework.

2.3.3 The NL Science Curriculum

As an attempt to standardize education across the province, and in accordance with the Pan-Canadian Protocol for Collaboration on School Curriculum proposed by the Council of Ministers of Education of Canada (see Appendix E), NL Schools established curriculum guides to help teachers organize what and how they teach each course. Each curriculum guide consists of a set of standards that are encouraged to be adopted across all disciplines, as well as outcomes designed for each subject. The NL curriculum guides articulate what students are expected to know and be able to do by the time they graduate high school; the guides standardize education through prescribed Essential Graduation Learnings (EGLs), General Curriculum Outcomes (GCOs), Key Stage Curriculum Outcomes (KSCOs), and Specific Curriculum Outcomes (SCOs) (*Science 1206, Curriculum Guide* 2018). The Science 1206 Curriculum Guide (2018) designed for Grade 10 students, focused on seven EGLs: Aesthetic Expression, Citizenship, Communication, Problem Solving, Personal Development, Spiritual and Moral Development, and Technological Competence. The current study will highlight the two EGLs most aligned with CRST: (i) Citizenship, where "graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context" (p. 2) and (ii) Spiritual and Moral Development, where "graduates will demonstrate understanding and appreciation for the place of belief systems in shaping the development of moral values and ethical conduct" (p. 2). These two EGLs pertain to the importance of recognizing rurality, and cultural identity in education, therefore they should not be overlooked in distance teaching.

General Curriculum Outcomes (GCOs). The first GCO from the NL Schools' Science 1206 curriculum guide (2018) titled, "Science, Technology, Society, and the Environment (STSE)" is declared to develop "[students'] understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology" (p. 20). The second GCO titled "Skills", pertains to the development of "[students'] skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions" (p. 20). Within the third GCO "Knowledge", students will "construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge" (p. 20). The fourth and final GCO is titled "Attitudes" as students "are encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment" (p. 20). The GCOs are comprehensive with Specific Curriculum Outcomes among the topics: Weather Dynamics, Chemical Reactions, Motion, and Sustainability of Ecosystems (*Science 1206, Curriculum Guide,* 2018).

Context for Teaching and Learning. The section "Context for Teaching and Learning" in the Science 1206 Curriculum Guide (2018) emphasizes several factors that make up the educational context in NL: Inclusive Education, Differentiated Instruction, Literacy, Learning Skills for Generation Next, and Education for Sustainable Education. Among these contexts, the review will further explore the curriculum guide's definition of inclusive education in terms of equity and diversity, as well as scientific literacy in terms of the Nature of Scientific Knowledge (NOSK), Western Scientific Knowledge (WSK), and Indigenous Knowledge Systems and

Practices (IKSP). These concepts from the curriculum guide are explored to identify the expectations of science teachers' instructional practices in NL and to demonstrate the fundamental similarities shared with CRST.

Inclusive Education. Inclusive education is defined by the United Nations (2017) as: "Education environments that adapt the design and physical structures, teaching methods, and curriculum as well as the culture, policy and practice of education environments so that they are accessible to all students without discrimination." (p. 3) Inclusive education is highlighted in the NL curriculum guides by encouraging the accessibility of instruction through fair opportunities for all students to learn (*Science 1206, Curriculum Guide,* 2018). Provincially, curriculum accessibility across the province has improved with instated distance education, although, inclusivity remains a challenge with the standardization of material as diverse communities merge for synchronous online learning. According to the Center for Inclusive Education, inclusive education should adhere to the following: supportive environment, positive relationships, feelings of competence, and opportunities to participate (*Science 1206, Curriculum Guide,* 2018). The following characteristics of inclusive education are outlined by the NL curriculum guides:

(i) All students need to see their lives and experiences reflected in their school community.

(ii) It is important that the curriculum reflect the experiences and values of all genders and that learning resources include and reflect the interests, achievements, and perspectives of all students.

(iii) An inclusive classroom values the varied experiences and abilities as well as social and ethno-cultural backgrounds of all students while creating opportunities for community building.

(iv) Inclusive policies and practices promote mutual respect, positive interdependencies, and diverse perspectives.

(v) Learning resources should include a range of materials that allow students to consider many viewpoints and to celebrate the diverse aspects of the school community (*Science 1206, Curriculum Guide*, 2018, p. 4).

Differentiated Instruction. Differentiated instruction can aid in developing inclusive classrooms and is defined in the NL science curriculum guides as “a teaching philosophy based on the premise that teachers should adapt instruction to student differences” (p. 5). Differentiated instruction can appear as differentiating the content, differentiating the process, differentiating the product, and differentiating the learning environment (*Science 1206, Curriculum Guide*, 2018). Place-based education (PBE) and experiential learning are among some of the educational theories that incorporate differentiated instruction and share features with CRT and CRST frameworks.

PBE represents differentiated instruction through the process of differentiating the learning environment. PBE incorporates the pedagogy of community, the reintegration of the individual into their home ground, and the restoration of the essential links between a person and their place (Sobel, 2004). Ark, et al. (2020, p. 104) describe PBE using six design principles: (i) Community as Classroom, (ii) Learner-Centered, (iii) Inquiry-Based, (iv) Local to Global, (v) Design Thinking, and (vi) Interdisciplinary; these design principles are defined as follows:

(i) Community as Classroom: where communities serve as learning ecosystems for schools where local and regional experts, experiences, and places are part of the expanded definition of classroom.

(ii) Learner Centered: where learning is personally relevant to students and enables student agency.

(iii) Inquiry-Based is grounded in observing, asking relevant questions, making predictions, and collecting data to understand the economic, ecological, and sociopolitical world.

(iv) Local to Global serves as a model for understanding global challenges, opportunities, and connections.

(v) Design Thinking provides a systemic approach for students to make a meaningful impact in communities through the curriculum.

(vi) Interdisciplinary values the curriculum connection to the real world, where "traditional subject area content, skills, and dispositions [are] taught through an integrated, interdisciplinary, and frequently project-based approach in which all learners are accountable and challenged.

In addition to PBE, experiential learning is another form of differentiated instruction with focus on differentiating the process through student experience. Experiential learning is described by the educational theorist David A. Kolb through his working definition of learning: "the process whereby knowledge is created through the transformation of experience" (1984, p. 38) and demonstrated using the cyclic process of:

(i) concrete experience,

(ii) reflective observation,

(iii) abstract conceptualization, and

(iv) active experimentation.

According to Kolb (1984), the learner first encounters an experience in the light of new concepts (concrete experience) followed by a reflection on the experience in the light of their existing knowledge (reflective observation), giving rise to a new idea or modification of an existing concept (abstract conceptualization) and applying the new idea to the world around them to visualize the outcome (active experimentation). The frameworks for PBE and experiential learning closely align with frameworks for CRST as culture plays a significant role in the communities from which students reside (sense of place), and a significant role in their experiences of science.

Science, Scientific Literacy, and Scientific Knowledge. The NL curriculum guides emphasize the need for students to acquire "a set of interrelated skills, strategies and knowledge in multiple literacies that facilitate their ability to participate fully in a variety of roles and contexts in their lives, in order to explore and interpret the world and communicate meaning" (*Science 1206, Curriculum Guide* 2018, p. 10). Among these literacies, the NL science curriculum design rationale for science education defines scientific literacy as "an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem solving, and decision-making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them" (*Science 1206, Curriculum Guide,* 2018, p. 19). To become scientifically literate, one must understand what is science, and henceforth, what is science knowledge.

Polkinghorne (1996) describes science as "socially influenced" (p. 11). In proclaiming something is socially influenced, we must be careful in defining science as it is seen through a societal lens; one that differs among societies. With regards to defining science, Polkinghorne (1996) claims that,

> The procrustean oversimplification of a fundamentalist reductionism will not begin to suffice. In fact, it cannot even embrace the practice of science itself, which calls for judgements of value (we seek elegant and economic theories) and whole chief reward is the experience of wonder at the rational beauty of the physical world […] The context of science is the human context; it is an activity of persons, involving unspecifiable powers of creative imagination. Science by itself is not enough to even describe the pursuit of science." (p. 2)

NL Schools' science curriculums describe science and scientific literacy with Western Modern Science (WMS) as its dominant discourse, in terms of Scientific Inquiry (SI) and the Nature of Scientific Knowledge (NOSK). WMS is a subculture of science with the prevalence of Western or Euro-American-centric culture (Lederman et al., 2014). Within WMS, scientific knowledge is combined with reasoning and critical thinking to develop skills in SI (questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analyzing data, and interpreting data) (Lederman & Lederman, 2020). The NOSK involves the characteristics of how knowledge is developed, and inherently, is embedded in SI as students observe the natural world (Lederman & Lederman, 2020). According to NOSK, knowledge is tentative, empirically based, and subjective (theory-laden), and derived from human inference, imagination, and creativity (Lederman & Lederman, 2020). In WMS, observations and inferences are critical to the development of scientific knowledge; to differentiate between the two, observations are descriptions of natural phenomena using the senses (e.g., the apple fell from the tree toward the ground), and inferences are statements regarding these observations (e.g., objects tend to fall to the ground because of "gravity") (Lederman & Lederman, 2020). The generation of Western Scientific Knowledge is dependent on inquiry processes and conceptual theories (Lederman & Lederman, 2020).

SI-based teaching and learning is becoming a staple in 21st century education, specifically with the emergence of STEM (the integration of Science, Technology, Engineering and Mathematics) as it is taking the forefront in curriculum design for the development of scientific knowledge among youth. STEM education reflects a more authentic approach to learning in the 21st century as it highlights the multifaceted and interdisciplinary challenges of the "real world" (Lederman & Lederman, 2020). The "real world" is the world in which a student resides (their own world—their society, and their community); teachings must be meaningful, and relevant in *their* world for authenticity to have meaning. It is a challenge to engage non-Western students in the sub-culture of WMS as these students are often asked to assimilate (when the subculture of science is at odds with their worldview and students are forced to adopt a different form of schooling at the expense of their own culture and lived experience) (Lederman et al., 2014). On the other hand, "enculturation occurs when the subculture of science harmonizes with a student's everyday culture and science instruction supports the student's view of the world" (Lederman et al., 2014, p. 292).

Indigenous Knowledge Systems (IKS) are far more than the binary opposite of Western knowledge (Aikenhead & Ogawa, 2007). IKS is not identified in the NL science curriculum currently. According to Aikenhead and Ogawa (2007), IKS may be described as (but not limited to) traditional knowledge, traditional wisdom, traditional ecological knowledge, Native science, Aboriginal science, Ma¨ori science, and Yupiaq science. The Eurocentric epistemological view of "knowledge" as a noun is translated into a verb— "ways of living" or "ways of being"—to characterise the expression more appropriately in the Indigenous language (Aikenhead & Ogawa, 2007). Aikenhead and Ogawa (2007) describe IKS as a process:

> The process of generating or learning Indigenous ways of living in nature is Coming to Know, or Coming to Knowing, phrases that connote a journey. Coming to Know differs from the Eurocentric science process to know (i.e., to discover) that connotes a destination, such as a patent or a published record of a discovery. An Indigenous Coming to Know is a journey toward wisdom or a journey in wisdom-in-action, not a destination of discovering knowledge." (p. 553)

Indigenous Coming to Know is rooted in experiencing the connection humans have with the natural world, whereas WMS is more concerned with knowledge as de-contextualized and compartmentalized, and acquired in a detached setting (classroom or laboratory) (Barnhardt & Kawagley, 2005).

The next section will identify the gap in the research pertaining to the practices of CRST within the context of distance science education in NL secondary schools.

2.4 Identifying a Research Gap

Factors such as the COVID-19 pandemic, teacher shortages, and advancements in technology have contributed to the growing demand for online education at the provincial, national, and global level. However, online education has been part of the NL education system since the early 1990s resulting in the development of the current CDLI program which was first established in 2001 (Saqlain, 2016). As described above, distance education, perceived as a tool to achieve equity for many students, may result as a tool of oppression, reinforcing the ideas of colonization due to a lack of integration of local culture and thought, disrupting student engagement in online settings. NL was the province of choice for the study due to its geography, unique history, rich cultures, its decades of experience with distance education in the public school sector, and its personal ties to the primary researcher as described in the above section, aspirations for this research.

There are fundamental differences between in-person and online science teaching. Among these differences are the learning environments where online learning tends to be more passive (e.g., listening to the teacher) than active (e.g., partaking in a hands-on activity to learn a concept). In the context of NL, difference between in-person and online classrooms includes the diversity of students in the classroom as they may live in vastly different rural communities, increasing their differences among lived experiences. CRST must recognize and include multiple worldviews and knowledge systems to allow co-existence of these in the science curriculum and classrooms. With emphasis on social, ethno-cultural backgrounds, and community building, CRST should be reflected in distance education programs, resulting in a need for research around recognizing rurality and cultural identity in teaching science by distance. The need for framing science education with rurality and culture using CRST is evident as the literature reflects on its' significance. CRST is implicitly supported within the NL science curriculum guides (through EGLs and GCOs), although how CRST is manifested in distance science education is lacking research and development (there are no studies demonstrating a framework for CRST in distance science education). The research ultimately aims to develop a framework for CRST that can be adopted for distance science classrooms for a more inclusive experience for students learning by distance.

Chapter 3: Methodology

This chapter provides a synopsis of the methodological design and procedures followed to conduct this research study. In the following sections, the research paradigm is discussed followed by an overview of the methodology including a description of the qualitative research design used, the participants, the data collection process, the analysis techniques used, the verification procedures, and a discussion of ethical considerations.

The purpose of this study was to explore how NL science teachers perceive and incorporate CRST in their science teaching practices by distance. The conceptualization and design for this research was guided by the questions: How are distance science educators making science culturally relevant for students regarding their rural homelands and community cultural identities? What challenges do distance science educators face with implementing CRST in the virtual classroom?

3.1 Post-Positivism Paradigm

The observable empirical-analytic views and naive realism (the attitude or practice of accepting a situation) of a positivist has limited educational researchers due to the nature of the social sciences (Panhwar et al., 2017). An alternative view would reject the idea that human behaviour is governed by universal laws; instead, a respect for what lies behind a "social reality" is deemed appropriate as the researcher works with external and internal realities, as well as fallibilism (Cohen et al., 2000). This alternative paradigm can be defined as post-positivism where ontological beliefs capture warranted claims rather than absolute truths, with a balance between naive realism and bounded relativism (knowledge is not absolute) (Panhwar et al., 2017). According to Kivunja and Kuyini (2017), the post-positivist paradigm provides a worldview for most research conducted on human behaviour typical of educational contexts, as the social sciences attempt to demystify, explain, and clarify the social forms humanity has created. I resonate with this paradigm as I find myself a critical realist where one believes in a shared reality mediated by our own perceptions. This paradigm has influenced the methodological design due to my own perceptions of research combined with the social scientific nature of the study.

3.2 Qualitative Research Methodology

A qualitative methodology was used to augment the benefits of voice in the context of the social sciences. Qualitative research was defined by Creswell (2014) as "an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem" (p. 32). The study of culture within the education system, including cultures midst the student body and cultures within science education (e.g., Western science and Indigenous scientific knowledge systems) are much too complex to encapsulate prevailing themes through discrete quantitative means, therefore, this study used qualitative analysis of interviews with thematic coding to provide a much deeper insight into science teachers' perceptions and use of CRST in distance science learning environments.

This study used a grounded theory approach to deduce a theoretical framework for CRST in the context of distance education. Grounded theory was defined by Creswell (2014) as "a qualitative strategy in which the researcher derives a general, abstract theory of a process, action, or interaction grounded in the views of participants in a study" (p. 292). The grounded theory approach to this study followed the steps outlined by Corbin and Strauss (2007), which involved generating categories of information (open coding), selecting a category, and positioning the category within a theoretical model (axial coding). A theory was deduced from the interconnection of the generated categories (selective coding).

3.3 Participants

Five participants were interviewed for this research study. The participants included past and present high school science teachers from the NL public school sector (NL Schools) who are currently teaching or have taught one or more science discipline(s) by distance through the CDLI (The Center for Distance Learning and Innovation). An inquiry email including the recruitment script (Appendix B) was sent to the CDLI director for the recruitment of CDLI science teachers; the CDLI science teachers who wished to participate were asked to contact the researcher by email (five teachers responded and consented to participation). Science courses offered by the CDLI pertain to those offered in grades 10-12 and include: Science(s) 1206, 1236, 2200, 3200, Biology/Biologie 2201, 3201, 3231, Chemistry/Chimie 2202, 3202, 2232, 3232, Physics 2204, 3204, Earth Systems 3209. The participants were expected to be a distance educator of one or more of the science courses listed above. No minimum teaching experience was required by the participants. No other limiting characteristics were used in the selection of the participants. Participants were asked three demographic questions in section one of the interview. These questions included:

A. How many years have you been teaching science in high school?

B. How many years have you been teaching science by distance?

C. What science disciplines do you have experience teaching (by distance)?

Demographic information varied greatly among the participants. The demographic information of the teacher participants is depicted in Table 1.

Table 1

Demographic information of teacher participants

Participant Pseudonym	Years of Experience Teaching Science in High School (In-Person and Distance)	Years of Experience Teaching Science in High School (Distance Only)	Science Disciplines Taught by Distance
Lily	10 years	1.5 years	Physics 2204 Physics 3204
Shawn	30 years	21 years	Physics 2204 Physics 3204 AP Physics 4204 Chemistry 2202
River	30 years	8 years	Chemistry 2202 Chemistry 3202 Science 1206
Louis	4 years	4 years	Biology 2231 Biologie 3231 Chimie 2232 Chimie 3232 Sciences 1236
Tessa	9 years	<1 year	Biology 2201 Biology 3201 Science 1206 Chemistry 2202* Environmental Science 3205* Earth Systems* 3209 Physics 2204*

*Disciplines taught virtually, although not through the CDLI.

3.4 Data Collection

Data collected included qualitative data from semi structured interviews to welcome everyday perspectives from the participants and to allow room for new perspectives from the researcher. Subjectivity remains the key to qualitative research in that the researcher makes meaning using a combination of their own pre-understandings with what has been observed or learned from the data and through the data collection process (Alvesson & Sandberg, 2022). Due to the important balance of objectivity and subjectivity in qualitative research, the data collection was guided by epoché. The term epoché was employed by Edmund Husserl, a philosopher in the

20th century, to describe the suspension of judgment, and it is used in research to eliminate preconceptions about the world when collecting data. A careful balance of epoché and the use of pre-conceptions was applied when conducting interviews (e.g., questions were posed with respect; interview answers were acknowledged without judgment). Although it is best to eliminate preconceptions, some prior notions were used in the research for the purposes of exploring its' basis (e.g., the preconception of there being tangible and intangible challenges with implementing CRST in distance education).

The data collection process included semi-structured interviews that were conducted online (using WebEX), audio-recorded, and transcribed with participants' consent. The participants' physical locations varied across NL and the interviews varied in length between 1-2 hours. The order of questioning remained the same for each participant, although their answers varied in detail. Prompts and follow-up questions were posed to ensure the participants understood the questions asked and to gather more information. The interview questions were designed by the researcher and categorized into four sections: (i) knowledge and source(s) of knowledge of CRST, (ii) practice and pedagogy, (iii) inclusion of students/parents/community, and (iv) challenges and affordances.

Section two of the interview included questions that were designed to provide context on participants' conceptualization of CRST. These questions included:

A. What is your familiarity with culturally responsive science teaching (CRST)? Other terminology may include Culturally Relevant Teaching (CRT), and Culturally Relevant and Responsive Pedagogy (CRRP).

B. Have you received any professional learning opportunities about CRST? If so, can you describe your experience? [Prompt: Was this experience science-focused? Did you learn anything that can be adopted to the science classroom?]

Section three of the interview included questions relating to the participant teachers' experience and practice with CRST in distance science education.

A. In what way(s) do you come to understand the ideas and experiences of your students regarding their culture and rurality?

B. In what way(s) do you make your lessons/teaching culturally relevant for your CDLI science students?

C. Explain how you may use the lived experiences of students, including your students' families, communities, and cultures, as valued parts of the instructional plan and discourse in your online science classroom. [Prompt: Can you provide an example?]

Section four of the interview included questions involving CRST practice with emphasis on the *inclusion* of students, parents/guardians, and community in science lessons by distance.

A. In what way(s) do you allow for a safe space through CDLI for students to discuss their cultures, and their communities? [Prompt: Can you provide an example?]

B. Have you ever allowed your students to discuss the socio-cultural issues important in their communities? [Prompt: If yes, can you describe this experience?]

C. Have you ever provided opportunity for CDLI science students to become involved in community advocacy through science as part of your lesson plan? [Prompt: If yes, can you provide an example?]

D. Have you ever included parents/guardians in the decision-making process regarding course content and delivery? [Prompt: If yes, can you describe this experience? What impact did their decisions have?]

E. Have you ever established collaboration with a community agency (a community from which one or more of your students reside) to enhance your lesson? [Prompt: If yes, can you explain this partnership? How did this allow culturally relevant experiences for your science learners?]

The final section of the interview, section five, included questions on the challenges and affordances of implementing CRST.

A. What challenges have you faced regarding making your teaching culturally relevant to your CDLI science students?

B. What challenges and affordances have the NL science curriculums provided you, to explore areas of cultural relevance and rurality regarding your students' interests and needs? [Prompt: Can you provide an example?]

3.5 Ethical Consideration

Digital informed consent was acquired by all participants before the interviews. Informed consent included the purpose of the study, the length of the study, the requirements by the participants, and the role of the researcher. It also explicitly welcomed and encouraged participants to ask questions prior to and during the research process. Participants were made aware that permission to forgo participation at any time would be granted prior to the cut-off dates provided, when data would have been aggregated for analysis. The names of the participating teachers were not mentioned in the study to respect confidentiality. Pseudonyms were assigned to the participants and data was made anonymous.

3.6 Qualitative Data Analysis

Data was transcribed from audio using the WebEX software. The interview transcripts were uploaded, organized, and analyzed using the MAXQDA software to increase the strength and credibility of the research by assisting to dissect the qualitative data into meaningful segments, revealing subtle patterns and relationships. Qualitative research software is created as a tool for assisting the research process, and not for replacing the role of the qualitative researcher because no computer can take the place of an insightful researcher who has intimate knowledge of the conceptual framework, the research questions and the participants. Ultimately, meaning was constructed by the researcher and the software was used as an assistive technology. A grounded theory approach was used to refine the data in multiple stages and develop interrelationships between categories of information. The thematic analysis involved (i) open coding, (ii) axial coding, and (iii) selective coding (Corbin & Strauss, 2007). The open coding process included conceptual labeling and categorizing of concepts found within the interview transcripts (e.g., online communication). A constant comparative analysis was performed throughout the process to determine common themes and linkages between codes, concepts, and categories (e.g., creating a safe space to communicate online). Relationships between the categories were established with axial coding and core categories were instated once conceptual density was reached (selective coding) (e.g., affordances of CRST). Conceptual density was considered reached after interviewing five teacher participants and analyzing their responses. Conceptual density is considered achieved when saturation is met. According to Glaser and Strauss, saturation is achieved when “no additional data are being found whereby the sociologist can develop properties of the category. As he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated” (1967, p. 61). The selective coding process used both deductive and inductive reasoning. Previous literature on CRT and CRST inspired the general concepts that were explored using pre-defined interview questions through deductive reasoning. The inductive reasoning approach involved the creation of new core categories to answer the research questions and develop a theory.

3.7 Limitations

The study design, anchored on teacher participants' relating their actions and perceptions of/with CRST is a limitation; in situ observations, student experiences, and the analysis of teaching/learning materials would make the results more reliable and provide a more fulsome picture of what happened in these courses.

Chapter 4: Findings

The purpose of this study is to explore how NL science teachers are incorporating CRST in their teaching practices by distance. Underlying philosophical assumptions of the study include the lack of familiarity among NL science teachers with CRST despite the evidence of its positive impact on student self-esteem and engagement (as discussed in the literature review), as well as the lack of implementation due to the added challenges—physical and scholastic—faced by distance educators, preventing them from incorporating CRST into practice. The study involved qualitative exploration via individual interviews to explore these assumptions with past and present high school science teachers from The Center for Distance Learning and Innovation (CDLI), a distance education program of NL Schools. The data included five participants (Lily, Shawn, River, Louis, and Tessa) who were interviewed by distance as their physical locations varied across the province. Their years of experience teaching science in high school (including in-person and by distance) varied between 4 and 30 years, and their years of experience teaching science by distance varied between <1 year and 21 years. Table 1 includes demographic information of teacher participants as well as details of science disciplines taught by each participant. The research questions for this study were: 1) How are distance educators making science culturally relevant for students regarding their rural homelands and community cultural identities? 2) What challenges do distance science educators face with implementing CRST in the virtual classroom?

4.1 Distance Science Educators' Conceptualization and Sources of CRST Knowledge

4.1.1 Conceptualization of CRST

All five participants revealed some conceptual understanding of CRST; however, they all lacked familiarity with the terminology, including the umbrella term *Culturally Responsive Teaching* (CRT), and the associated term *Culturally Responsive and Relevant Pedagogy* (CRRP). The participants demonstrated understanding and experience with similar concepts, such as authentic education, place-based education, experiential learning, and individualizing the curriculum. Lily did not remember if she had heard the terms before, but expressed her general understanding, "I have heard, I guess, variants of [CRT]. I don't think I have heard any of those specific terms tossed around before." She recalls experiences from her Master of Education program:

> I've been trying to remember the terms that I have heard, and I truly cannot. But I know that when I was doing my Master of Education, I did a course in science pedagogy, and we touched on some Nature of Science, and we talked a little bit about cultural appropriation, misappropriation, that sort of thing.

Shawn's understanding included the concept of individualizing the curriculum. He said, "The term is self-explanatory, although, you are probably the first to drop it for me…I think my reading of *individualizing the curriculum* probably overlaps a fair bit with the modality of culturally responsive teaching." To Shawn, the concept appeared to be both important, and customary to everyday teaching:

> [I] did not know that term, culturally responsive teaching; [however, I] knew that you are going to lose the kids if you are not there with them, respectfully listening to them and

> responding to them…So, it turns out that, for the most part, this whole culturally responsive teaching is just a part of the day-to-day activities.

Shawn did not have familiarity with the terminology, although he showed an understanding of the concept by historically speaking on the intricacies of science education in the rural setting, and the present-day expansion of science by amalgamating it with rurality, forming a new culture,

> In a backwards sense, what we are doing here [regarding distance education] is that we are taking the whole ethos of science and bringing it to kids who would not otherwise have it. So, this is a different culture. Instead of taking the local culture of the community and bringing it outward, we are taking a different culture that historically did not really exist nicely in the community, and bringing it in.

River also expressed her lack of familiarity with the term CRST. In her words, "I have never heard of those terms before." Louis, also without knowledge of the terminology, predicts the meaning of CRST as "making the material as authentic as possible so that the kids could have a link to it and relate to it." Tessa expressed her knowledge that CRST involves making content relevant to students. In her words,

> If not the exact terminology, the concept was introduced in my initial teacher education program. It's not a very big stretch from the idea that's constantly talked about in education: making content relevant to students. But obviously, it is a specific element of a students' world, when we talk about their culture.

4.1.2 Sources of CRST Knowledge

Two among five participants (Lily and Tessa) spoke of professional learning opportunities (PL) that touched on aspects of CRST. Most of these opportunities availed themselves within their initial teacher education programs, graduate studies, personal readings, and school-sponsored information sessions. In Lily's words, "I have participated in professional learning regarding Responsive Teaching and learning" however, "none of those opportunities were specific to science education". Similarly, Tessa said, "I do not think I have ever had PD [professional development] days focusing specifically on culturally responsive teaching," [however], "In my initial teacher training program, there were classroom discussions about [CRT] and . . . [a few] readings about it." During her graduate studies, Tessa took a few courses which she found close to the idea of CRST. For example, she took a course on "place-based education, which [was] very much focused on culture." She believes that place-based education and CRT "are closely related concepts." She also took another graduate course regarding "experiential learning, which ties in a lot of the components around CRT, particularly in the case of NL." Tessa said,

> I participated in a PL in my first year of teaching called The Oceans Learning Partnership, which was not on CRT specifically, but it was about hands on experiential science learning. It had elements of incorporating NL culture into [science education].

She further explained,

> When we talk about NL culture, it is a culture that is very deeply tied to the land, and so I think anytime we practice experiential or placed-based education, or have discussions around the local ecosystems, and our relationship with it, it becomes culturally responsive teaching.

Although there is a general lack of familiarity with the terminology among all five participants, they appeared to have their own understandings of what it embodies. The next section will uncover their individual experiences with CRST in practice.

4.2 Distance Science Educators' Implementation of CRST in Practice

All five teacher participants lacked familiarity with the term CRST, however, each participant incorporated CRST practices in their distance science classrooms. The teacher participants' responses included their practices and experiences implementing what they consider to be CRST. These responses were coded into two themes (i) affordances and (ii) application. As a precursor to practicing CRST, affordances were discovered as the preceding actions of the teachers that were deemed critical to the succeeding application of CRST. Affordances included ways distance science educators allow students a safe space to discuss and express their cultures and rural identities. It is within this safe space that communication can allow for the students' voices to emanate—a vital component to an educator's knowledge and understanding of the students' cultures and identities. The second theme, application, includes examples of how distance science educators incorporate CRST into their science classrooms by distance through culturally responsive science projects and subject matter.

4.2.1 Affordances: The Precursor to CRST Application

Affordances became evident as an important requirement to CRST application through the teacher participant responses. A common affordance among all teacher responses included creating a safe space to allow for student voice. The most authentic way to learn the complexities of students' cultures and rural identities is to learn from the students themselves—demonstrating student voice as a critical affordance to CRST application. The students must feel safe to share about themselves, hence the need for creating a safe space. The teacher participants discussed how they create a safe space within their distance classrooms by (i) showing interest in their students' lives through different techniques in communicating online and (ii) respecting student cultures and rural identities through recognizing and celebrating the differences among students, honoring students' local dialects, and ensuring that the students' cultures and rural identities are represented in science.

Creating a Safe Space for Student Voice through Communication by Distance. It became evident through the teacher participant responses that the teachers' knowledge and understanding of their students' rural and cultural backgrounds stemmed largely from communication. Cooperative and responsive communication with students was demonstrated by the teacher participants as a critical aspect in allowing a safe space for students to express themselves. Communication techniques that were discussed in the interview responses were found to include informal and formal communication styles using various platforms and methods tailored to make the online environment feel more secure and inviting for students to represent themselves as individuals in the distance science classroom.

All five teacher participants discussed their use of informal communication by distance during their online classroom sessions to make their students feel safe and familiarize themselves with their students' cultures and rural identities. Shawn shared his thoughts on the importance of informal communication with his distance science students. He explained how distance education features the added challenge of not being face-to-face when communicating, where an uncomfortable disconnect is illuminated between students and the online teacher. Shawn stated:

> We had to build a social structure in our class, and we knew that right from the get-go. We knew it was vital—and more vital than the face-to-face classroom. And so, creating an online culture was incredibly important…You would always start class by chatting about what was important to the kids' lives…The best way to draw the kids in is to let them *talk*. You would say a few words, "How are things today in such 'n such place..." and you would shut the hell up and let them tell you how things were that day.

Lily expressed the importance of engaging with all her students individually because of their broad differences in locations and therefore extensive differences in life experiences. In her words, "It is an interesting dynamic because [the students] are from many different areas across our province, which sounds like it would be uniform in terms of culture, but it is truly not…their experiences cannot be compared to one another." Getting to know all her students individually, Lily described as important because, "They have all lived very individualized lives with different day-to-day routines, beliefs, cultures, and morals." Lily explained how informal communication may help her learn aspects of her students' cultures and rural lifestyles. In her words, "I can get a feel for what their extracurriculars [activities] are, what their family life looks like without getting too personal, to understand what it is that they do day-to-day that may be different from my way of life." She added, "I try very hard, at the start of every class to have small talk. I greet every single student, every day". The teacher participants used examples of how they begin their online sessions by casually asking their students questions, such as: "How is everybody doing?", "What did you do over the weekend?" "What is it like out where you are?", "Do you have any plans that you are looking forward to?" and "What are your goals for this month?" Using an informal communication style, River also spoke on the differences between her students' environments and cultures that often transpire from the conversation. She expressed, "Obviously [their environments] can be very different…it is very casual to get a feel for what kind of things they do and what life is like where they live". Tessa described her use of informal communication as a casual way to learn more about their students in authentic ways. Tessa explained, "You can get glimpses of their culture in those informal class discussions."

Informal discussions have proved to help teacher participants create a safe space for students to share about their students' cultures and rural identities. Among the topics of informal conversations with students, weather appeared as a common theme among the teacher participants. River and Louis considered conversations concerning weather as another way to connect students from various parts of the island and a way to learn about their different cultures. According to River, “It’s common to talk about the weather when you're teaching kids from all over the place. You might have one class with students from five or six different communities, including those in Labrador.” Similarly, Louis explained how it can be interesting to make comparisons on what is happening in the East, what is happening in the West, and what is happening in Labrador regarding weather. Louis mentioned, “We talk about what is going on in their areas…we sort of compare, because we are all in very different parts of the province.” Topics of discussion have also shown to manifest into important discussions on sociocultural issues that are pertinent to students’ personal lives and communities. Lily explained how she allows her students to discuss sociocultural issues when it comes up organically, and it is “important that [teachers] do that.” Lily expressed,

> It is not something that I tend to bring up, mostly because in some classes there are approximately 25 kids from 23 different communities, although, sometimes, there are only 10 kids where 8 of them are from the same community and if something important happened in that community in the past 24 hours, it is at the top of their minds and it is something they might want to air out.

For students to feel valued and respected in conversation, the teacher participants expressed the need to be responsive in those conversations. Responsiveness might appear as a follow-up question, an expression of shared interests, relating to an aspect of their day-to-day lives, or genuine concern or appreciation for their contribution. Responsiveness had shown to promote student engagement for both River and Louis as they discussed how they use shared interests to connect with their students regarding aspects of their cultures. Louis explains,

> I like to have a chat with the kids, especially after a weekend, regarding what they are up to on the weekends, because a lot of the students in small towns go hunting, fishing, or they have a campfire… things like that. So, we sort of chat about that because I also like some of that stuff too or do stuff outside on the weekend.

Louis expressed how he enjoys connecting with the students on shared interests by sharing pictures of his own outdoor adventures; by sharing his own pictures, students are then encouraged to partake and share some of their own, he described, "Sometimes, they might share a picture of a campfire they built, or a cabin they went to". River also described her personal experiences with NL culture, and how it helped her to connect with her students,

> I grew up in rural NL for the most part… my uncle fished, but it wasn't his full-time employment, and then I had grandparents who lived on the southern shore where I went every summer. Berry picking was very much part of my life…So, I feel that I can relate to a certain degree with what these kids are doing and what I've learned, for the most part, is that they all love where they live.

River explained how important these interactions are, "It's very important to foster these relationships so you're not just this voice on a computer screen, because very often they may not think of you as a real teacher. It's important to foster those relationships from the beginning." Being responsive to students demonstrated to be an important part in learning about students' cultures in a respective way by creating a safe space in doing so.

In addition to informal conversation, the teacher participants indicated their use of online platforms to showcase information that students share about themselves, making it accessible to their classroom teachers and classmates. Both Lily and Tessa use online “Digital Lockers” which they described as interactive notebooks and slideshows within Google Classroom and Brightspace. Lily uses a digital locker on Google Classroom to learn information about her students. She asks her students to include aspects of their lives such as their hometowns, the name of their community school, what they like to do for fun. Students have the option to include pictures if they want to. Lily said, “I really want to get to know on *who* I was working with, where they are located, and if there is anything [common] among the students”. Tessa described her use of the Brightspace Digital Locker. She explained that her “students would put items or photos in the locker that represents who they are.” She further explained that the student-made digital lockers are located on a discussion forum in Brightspace where the students would be able to respond to each other's lockers. Tessa explained how some elements of the students’ lockers may highlight and portray aspects of their cultures. In her words, “There were [students’ lockers] with some cultural elements such as hunting and fishing…especially land-based activities.” Tessa reflected on these elements from her students' lockers and saw them as “being connected to NL culture.” Instead of digital lockers, River and Louis described their use of digital questionnaires to better understand their students’ identities. According to River and Louis, these digital questionnaires were designed to be filled out at the beginning of the school year to help the teacher learn what their students’ interests, activities, and goals are.

Creating a safe space for students to comfortably share their ideas, opinions, and identities during online classroom sessions can be challenging. Using technology to their advantage, the teacher participants discussed their use of the Zoom software (the communications technology supported by CDLI) in promoting responsive communication with students. While using Zoom for science lessons, the teacher participants clarified that their students are not required nor pressured to use their cameras or microphones. Instead, students prefer to use the "chat feature" as their primary mode of communication. Tessa said, "While we are on our zoom meetings, a lot of students prefer to use the direct message feature rather than the microphone". The chat feature on Zoom allows for communication between the teacher and the students through message format. The chat feature can be used to address the entire class or used for direct messaging. The direct messaging feature was described by the teacher participants as a unique affordance for distance educators to create a safe space online. This safe space manifest itself through the ability for students to share information to the teacher without the pressure of an audience. River described her experience using the direct message feature on Zoom as "the most powerful thing the [Zoom] software has to offer." In her words:

> Imagine being in a [physical] classroom and you are writing an example on the board. You ask, "What is the answer to this problem?" Only a few kids might answer…some kids are just too shy, and nobody wants to be wrong…With the private chat, I can get them all to answer [in real time], and no one can see anyone else's answers. It is informative for me.

All teacher participants discussed their use of the direct message feature in creating a safe environment for students to communicate online. River explained how useful and fun the platform can be in developing a respectful classroom community. She provided an example, "I will ask my students to let me know when they step out, even if they use an emoji like the coffee or the hand wave; I think that builds trust and respect…which is important for creating a safe space online."

All five teacher participants discussed their use of another popular feature within the Zoom software: Breakout Rooms. Breakout Rooms provide an online space for smaller groups to form within the online classroom setting. These smaller groups allow for a more comfortable environment for students to engage in group projects and discussions. According to River, "The students are usually more open to collaborating here [in the breakout room]. They get more comfortable, and this helps them get to know me more on a personal basis as well. I find that it is a real game changer." River explains the communication style within breakout rooms. She said:

> It's more of a back-and-forth kind of interaction, I try to help them expand their undertaking of what kind of project they want to do; they might have an idea, I will have some suggestions, and we kind of hash it out together—it's collaborative, it's not me telling them what to do. That really helps build trust and respect.

Tessa also spoke on her use of Breakout Rooms. She said, "I have [used] breakout rooms with students so that they can discuss something in a smaller group setting. They feel more comfortable that way." Providing students with various modes of communication to feel comfortable and safe in the online setting demonstrated to be important for students to feel they can share, not only academically, but about themselves and their cultures. The online classroom environment must feel safe and inclusive for them to be their authentic selves.

CDLI students usually login to their distance science courses from a computer lab or a small classroom in their community schools. Lily described how students can sometimes engage in a lesson from the comfort of their own home. When given the opportunity to login from home, Lily explains how her students are usually more comfortable and therefore willing to use their cameras and interact over the microphone during science lessons. She reflected:

> On snow days, the students tend to be eager to log on from home…It is the neatest thing to see. We made it a thing this year that if you had a snow day at your school, you could wear your PJs or your hoodie or whatever is cozy, get your hot chocolate, curl up on your

couch, and we do physics together. They thought it was the most awesome thing. I don't know how it came to be, but that was a culture that we created upon ourselves, the cameras were on, and it was magical. It really was like people started to connect nicely.

In addition to communicating over Zoom, Lily described her communication style as a "virtual open door" as not to limit her interactions with her students to the instructional period. She described her use of email as an opportunity to "emphasize and connect" with her students, which will inherently help create a safe space for students to express themselves. In her words:

> I have a mostly 24/7 (virtual) open door policy…If students email me with questions about their work or have requests for extensions, that is when I get the chance to empathize or connect. I find email to be a valuable tool for me because it gives me more time [with the students] … I get more information from them that way, which is nice.

Lily expressed how her communication extends to parents, and guardians to promote an inclusive environment. Lily described her interactions with parents and guardians as "a lot of emailing." Lily feels it is important to include parents and guardians in conversation when creating a safe space for students online. In her opinion, communication that extends past the student, to their families is important. Lily explained, "It is great to make that connection because communication usually means better understanding. So, if anybody is not on the same page, it is much easier to collaborate and have a chat". Throughout the year, Lily strives to meet with anyone who wants to speak to her, whether it be on the phone, a Zoom call, email, etc. She suggests, "I am more than happy to do so, and I appreciate if they have feedback or concerns; I want to hear it, whether it's positive, negative, or indifferent." CDLI also offers virtual curriculum night for families. Lily shared, "We have virtual curriculum night which all parents, guardians, and students are invited to, and we also have parent teacher interviews". Through the teacher participant responses, it became evident that communicating with families allowed the teacher participants to learn more about their students' cultures and what is important to them and their families, and communities.

Despite the affordance of digital communication by distance, all teacher participants expressed a strong desire to meet their students in person, as there remains some degree of disconnect between the students and the teacher. Two teacher participants described having the opportunity to meet their students face-to-face through CDLI-sponsored events. Shawn remembered being sponsored to travel to Nain, Labrador. He spoke on this venture, "We would make sure the Internet connection was working, we would make sure that we did team training on site while we were up there, and we would make sure that we had time with the students." Shawn emphasized how meeting the students became the most important part of the trip. He said, "Training was important, but most importantly, teachers and students became real to one another." Lily also had the opportunity to meet her students by taking part in a CDLI-sponsored field trip. She described,

> We had a physics field trip this year, which in terms of culture, was completely mind altering…We had a bus with a couple of teachers that began its trip in Rocky Harbor. We picked up students all the way across the island and brought them to St. John's for three days where we did fun educational activities before we brought them all back home again.

Lily defined her experience as illuminating, "It was amazing to meet them in person. What you have in your mind's eye versus what *is* can be so different—and that is where the cultural responsiveness gets me. It is a complex thing". Meeting students in person is not a common occurrence for CDLI teachers, although those who had the opportunity (Shawn and Lily), expressed their gratitude for the experiences they had. Creating a safe and inclusive opportunity for students be share about themselves extended beyond the digital walls to in-person experiences where the teacher participants were able to learn more about their students.

Creating a Safe Space by Respecting Student Cultures and Rural Identities. It was determined from the teacher participant responses that respecting student cultures and rural identities involves: (1) recognizing and celebrating the differences among students, (2) honoring students' local dialects, and (3) ensuring that students' cultures and rural identities are represented in science. When students feel respected, students are more willing to share about themselves and contribute to science lessons. When students share about themselves in the distance science classroom, distance educators can acquire the knowledge they need to implement culturally relevant subject matter in their science lessons.

Louis discussed ways he creates a safe space for students by recognizing and celebrating the differences among his students. Louis expressed,

> No matter what a student may bring to the classroom, I try as much as I can to respect their differences…If a student may like something that nobody else has an interest in, I try to celebrate that…I am welcoming to creating a safe space, so kids feel comfortable.

Tessa expressed the importance of recognizing and "appreciating students' cultural activities." She said, "I sometimes see that students have to take time out of school—this could be for a community event, for hunting, or for fishing." She mentioned that some teachers "have a very negative view of this phenomenon" and that she feels "it is important to take time to learn about the activities that the students are missing class for and to see the value in them." She described her belief in that a teacher must be "flexible and creative in finding ways to help students stay on track with the curriculum while also appreciating and finding connections in the activities they are engaging in.” According to Tessa, students’ lives outside of the classroom can be just as educational or more than a classroom lesson, and their activities can easily be tied to science curriculum content. In her words,

> A student who misses a week of classes to go moose hunting could be learning so much in that time…I like to ask them to take photos and to share what they learned with the class when they return, which can be a valuable learning opportunity for everyone.

Shawn, Tessa, and Lily described the need to remove academic armor at times to respect students’ personal lives. At times, community and/or cultural activities may interfere with the teacher’s lesson plans. Creating a safe space for students to participate in community and/or cultural activities requires understanding without reprimand when students may need to be absent from school or science lessons. Shawn and Tessa both expressed that their students’ lives are rich and filled with educational possibilities beyond the classroom. Shawn provided an example by describing a scenario when all his distance science students were absent from class to participate in the community caribou hunt without his knowledge. He reflected:

> There was about six or seven of them in the class, and not one of them were online that day. So, I called up the principal of their school and she responded, “Oh, Shawn, I forgot to tell ya! The caribou are in, I forgot to call ya! When the caribou come in, the whole community goes huntin’.” “Alright then, best kind” I said.

Shawn also mentioned how his distance students’ lives outside of the classroom factors in his decision of *when* and *if* to give homework. He described,

> It seems that on the North Coast of Labrador, the kids have very rich lives after school. There is community Saturday they will all go to. They love their skidoos, and they have

> great hunting and fishing. So don't mess with it. Just don't mess with it. Let that part of their culture play out and find other ways around it.

Lily learned from experience that altering her teaching schedule may be required to allow for a more inclusive classroom when community, family, and personal priorities of her students do not always resemble her own. She provided an example,

> When I started teaching, my reaction to [missed school] would have been totally different from what it is today…Now, when a student says "Miss, I am going out on the crab boat now for a week" or "Miss, I'm going moose hunting," or "I'm going on the caribou hunt", I cannot get angry at that [because] that may be the family's source of income, and it may be a very important part of their culture.

Honoring students' local dialects appeared as a significant factor in respecting students' cultures and rural identities. Tessa explained how respecting students' cultures and rural identities must include respect for language and dialect. In her words, "I think honoring students' accents, local dialects, and ways of speaking is so important." She provided an example, "There is a long history of Newfoundland rural accents and vernacular being mocked and looked down upon." She proceeded to explain how a teacher's comments can be harmful to student self-esteem, therefore careful attention to respectful language is essential. In her words,

> Teachers who are not from rural areas, or those who do not have these accents, may be inclined to correct students on the way that they speak. I think this is incredibly sad as Newfoundland and Labrador's many varied accents and ways of speaking are such a beautiful part of its culture. I think that [correcting students' dialects] puts up a barrier by making students feel as though they cannot engage in science while being their authentic selves…I think the appropriate approach is to engage students in a direct discussion about

> the biases that exist. We can teach them that they may choose to use different language in different settings to navigate those biases or to ensure clarity rather than teaching them that the way they communicate is incorrect, improper, or less than.

Ensuring that students' cultures and rural identities are represented in science was determined to be another way distance science educators can create a safe space with respect. Tessa described how she represents her students' cultures and identities when engaging them in a discussion of *what is* science, and *who is* a scientist. This representation is meant to create a safe space for her students to feel accepted and encouraged to participate in science. She explained, "I think finding role models of scientists who students can relate to is important; this can include Newfoundlanders and Labradorians, people from rural areas, people with accents, or people who work in various fields." Tessa reflected on a role model who had a positive impact on her as a science student. She shared:

> I was in my fourth year of university when a guest speaker came to one of my [science] classes to give a presentation. [The guest speaker] had a prominent Newfoundland accent and spoke about very interesting and important work. It really struck me. I was the first person in my family [from NL] to go to university…[and] I had a few professors from NL. For me, there was a big disconnect between identifying with my NL culture and identifying with academia and science. That guest speaker really made me question the way people are expected to be represented in science and academia.

4.2.2 Application: The Practice of CRST by Distance Educators

The teacher participants shared examples of incorporating CRST into their science lessons by distance. According to Ladson-Billings (1995), CRT involves cultural competence and critical consciousness from the educator. The examples of CRST shared by the teacher participants in this section were deemed culturally responsive due to the substantiation of cultural competence and critical consciousness applied to the educators' practice and pedagogy. The teacher participants demonstrated their recognition of the differing beliefs, ideologies, and values that coexist in their distance science classrooms in their interview responses, embodying the cultural competence aspect of CRT. By respecting these characteristics in the student body, the teacher participants unveiled a "social awareness," which denotes the critical consciousness of CRT where teaching and learning are not separate from social justice and democracy in DCE—a practice that is strongly encouraged in the NL science curriculum guides. It was evident that the teacher participants held CRT competencies in teaching science, therefore, this study will deem the examples provided by the participants as examples of CRST. This section of the study includes teacher participant examples of CRST in terms of (i) Culturally Responsive Project-Based Learning (CRPBL) and (ii) Culturally Relevant Subject Matter (CRSM).

Culturally Responsive Project-Based Learning in Distance Science Education. CRST in distance science classrooms was demonstrated by the teacher participants through their use of project-based learning (PBL) in science lessons involving community, local scientific knowledge, and relevant socio-scientific issues. The examples provided by the teacher participants were classified as examples of CRPBL as they integrated elements of community involvement, local scientific knowledge, and relevant socio-scientific issues with scientific outcomes.

Community involvement in science projects became important to River throughout her teaching career as she expressed the positive impact it had on her students' involvement in science. River uses open scientific inquiry when assigning science projects. She encourages her students to envision their own topics by looking within their own communities for potential scientific issues, or areas of interest. River shared, “I encourage [my students] to look for an issue in their own community…I encourage them to talk to their parents, guardians, elders, or other members in their communities.” River justified her practice, “I found that if the projects relate to where the students live or if they take [their projects] personally…they seem to take more ownership, rather than just searching the Internet.” River reflected on a past student’s science project she considered culturally relevant. The project involved measuring the temperature of ocean water and taking note of when and how ice is formed. Due to her students’ interest in the topic, River decided to contact SmartICE (Sea Ice Monitoring and Information Inc.) SmartICE agreed to a presentation for River’s online science class. According to River, SmartICE is “very much community-based”, and their presentation gave her students insight on what the organization is about, and what is happening today regarding climate change and ice formation in NL coastal regions. River shared that the presenters were university students, and some of them identified as Indigenous from the same communities as some of her students. River conveyed, “It [was] empowering for the students to see themselves [represented in science] and learn the impact climate change is having on Northern communities.” From this presentation, one of River’s students became interested in the changing ice patterns and how it affected aspects of her Indigenous culture with a focus on the seal hunt. This student shared with River a personal experience which River had recounted, “She [had] participated in the seal hunt every year since she was nine, and recently, had noticed that the ice was late to form and melted sooner, so the quality [of the ice] was no longer appropriate for the hunt.” As a science project, the student surveyed elders among other members of various communities in Labrador who partake in the seal hunt as she “wanted to know what their experiences were [regarding changing ice patterns and its effect on their experiences hunting seal].” With this information, River said, “[the student] was then able to make a connection between her own data and the data collected by SmartICE.” According to River, the science project was extremely engaging and educational. In her words, “It was powerful because I believe it was a great example of respecting Indigenous peoples’ culture and knowledge through the two Ways of Knowing science.” River practiced CRST when encouraging her students to look within their own communities for science project ideas and providing access to relatable content by inviting SmartICE to her classroom. This practice involved CRPBL by incorporating the three elements: community involvement, local scientific knowledge, and relevant socio-scientific issues in science projects.

River inspired many other students to study scientific phenomena within their own communities, permitting CRPBL through her use of CRST. One of River’s students became interested in the water quality in her town due to the reoccurring “boil water” advisories (a common occurrence in many rural NL communities). Due to this curiosity and encouragement from her teacher (River), the student decided to research the issue by testing the quality of the town water and investigating the source of contamination. Another science project stemmed from her students’ interest in salmon fishing. According to River, “A couple of my students noticed that their [salmon] catch was going down year after year, and that water temperature had been going up. So, they figured that there may be an affiliation.” The partnered students interviewed NL salmon fisherman on what they had experienced, if they had noticed a change, and what they believed to be the cause of the change.

Another example of CRPBL in science presented itself when River’s students showed concern about beach pollution in their coastal communities. As a project, her students decided to “keep track and classify the type of waste found on beaches” by using a mobile App. Two students from two different and distant communities were interested in collaborating by providing “an inventory of plastics and comparing their findings from both beaches.” The students found that “one beach had a lot less waste than the other and [they] wanted to analyze that.” Through their analyses, the students became aware of the different ocean and weather patterns that exist in each coastal community as “the beaches were in very different parts of the province.” According to River, the significance of the project became clear to her students. She explained, “The students learned to educate people in their communities, and the other students in their classes on beach pollution, and the tools they used to make beach clean-up fun.”

Another one of River’s students chose to produce a science project using her own chickens. She investigated how the mass of poultry eggs would differ when the hens were fed different diets. River explained, “It was a good example of measuring something changing over time, sample size, controlling for variables, etc.” She added, “It was something relevant to their lives.” Smallholdings of chicken livestock for family and/or local use are common in NL rural communities. This student-led project was culturally relevant to the student, and it allowed for classroom discussions on sustainable NL farming, and the nutrients gained from locally grown and raised animal products.

In addition to student-led projects, the teacher participants shared examples of guided scientific inquiry exercises through culturally relevant laboratories and other hands-on activities by distance. River, Louis, and Tessa described their use of students’ geographical areas for their lessons in ecology. When teaching ecological systems, River asks her students to collect raw materials where appropriate and take pictures of their natural environments to share with the class because “everyone is in a different area.” According to River, the activity is meant to engage the students by involving them in nature and to help them make connections between their environments. In this activity, River expressed “how much [the students] love where they live and how proud they are of where they are from" through the descriptions shared by her students of their surrounding natural environments. Louis also incorporates his students' natural environments in his science lessons when teaching population biology. Louis "revamped one of the [curriculum] activities with the option of going to a nearby bog to sample populations." Louis shared that NL bogs are plentiful with a rich diversity of organisms that can be used to teach about ecology, specifically populations and sampling techniques. When guiding this activity, he provides his students with a choice in the type of organism they would like to sample. He described the process:

> I get the kids to their nearby bog, walk through it, and sample these populations. They count the number of, for example, pitcher plants that they see on transacts and then they calculate what the population of the pitcher plant would be for the whole bog. They use Google Earth to get the size of the bog, and then they can extrapolate the total population.

Louis described the activity as "an opportunity to get the kids connected with their environment and see what is there." He claimed, "A lot of the kids come back with feedback that they discovered new things, such as the realization that bogs have so much diversity." Louis mentioned that some of his students became interested in sampling "the birds found in the main river area where they live, or trees that are closer to [one community vs. another]." Lily shared her thoughts on changing laboratory experiences from confined physical classrooms to outdoor environments and using materials from nature instead of man-made or purchased scientific equipment. She said:

> I feel that labs could easily be tailored to specific geographical locations…If the students feel [science experiences] are making a difference or that it is related to the community,

they will be more engaged…They need to have some kind of attachment to light that spark.

Shawn shared similar thought on engaging students with science laboratories made relevant to their communities and culture. He shared an experience of using culturally relevant materials when teaching a biology laboratory exercise in a rural community; although his experience did not pertain to his courses in distance education, he mentioned that the exercise could be possible by distance if organized with appropriate teacher supervision within the individual schools. His example of a culturally relevant biology laboratory involved switching from dissecting frogs to dissecting rabbits that were locally caught and offered *by* the students. In his words, "The kids were much happier dissecting a rabbit than they were dissecting a frog because the rabbit was relevant—the rabbit was something they produced themselves." Shawn explained that this change helped students take the activity "way more seriously."

PBL, when combined with CRST, was termed CRPBL in distance science education for the purposes of this study. The various examples shared by the teacher participants incorporated community involvement, local scientific knowledge, and relevant socio-scientific issues when teaching science using hands-on activities guided by distance educators. CRPBL was determined to be engaging due to its relevance in students' lives.

Inclusion of Culturally Relevant Subject Matter. All five teacher participants demonstrated CRST through their use of culturally relevant content in their science lessons by using examples that were tailored to make the content of their science lessons more relatable to their students' lives. The teacher participants shared their use of culturally relevant examples when teaching fundamental concepts in science. The instructional suggestions provided by the NL science curriculums to teach scientific concepts are "relatively generic" according to Lily.

Therefore, Lily uses examples from her students' local communities to include in her science lessons. Lily explained, "When I started teaching, I would have never written about a *quad* doing something *around the bay*. But now, almost every unit includes something about a *quad* or a *skidoo* because that is what the students understand." Lily's use of the words "quad" and "Skidoo" were intentional as these are the preferred terminologies for ATVs and snowmobiles used by many Newfoundlanders and Labradorians. These outdoor activities are very popular among the people in NL, especially teenage youth in rural areas for recreational use, and for essential means of transportation through wooded and snow-covered areas.

Shawn also discussed his use of culturally relevant examples in teaching science. In his words, "It was not very hard for me to make [science] relevant. Basically, I would talk about something the [students] know…[like] pulling in the boat with rope…I mean, you do not want to talk about something they do not know." Shawn proceeded to reflect on using relevant examples by sharing a memory from a past student. According to Shawn, his student shared, "Every time [Shawn] did a physics problem, [he] would use something from the community, and when [he] did problems on acceleration, it was always Cameron's skidoo!" Shawn justified his use of culturally relevant examples by saying, "It must have been important because this was decades ago, and [my student] still remembered it."

Tessa provides her students with "opportunities to talk about their culture(s) and how their experiences may relate to the [science] curriculum." This affordance, Tessa described, provides her with culturally relevant examples to be used in future science lessons. Tessa uses location-based examples in the weather unit of Science 1206 by using the "whiteboard" feature on Zoom. This feature allows her to display a large map of Newfoundland and Labrador where her students can add where they are located and the current weather in those locations. Tessa explained how she expands on the activity by asking her students to "describe why it would be important for them to have a weather forecast." Tessa claimed that "a lot of [the students'] answers were culture-based, including reasons involving recreation on the land like driving skidoo, driving quad, hunting, fishing, and checking traps." She also reflected on her use of socio-cultural examples when teaching the weather unit. Tessa described,

> If we are talking about jet streams, we might talk about flying from NL to Calgary versus the other way around, and how much faster it is to fly in one direction versus the other. When we are talking about wind patterns, we are also talking about who has been to Alberta—as a lot of [NL] people have family members working abroad. I think that is a major part of NL culture today, as many families have members involved in *turn around* work.

Tessa's use of culturally relevant examples presented themselves in other areas of science as well, including discussions of anatomy during biology lessons. Tessa shared, "I will ask my class, 'who has ever been moose hunting?... When you catch a moose, a lot of people grab the trachea and pull it out. Has anyone experienced this? Can anyone recognize all the rings on [the trachea]?'" According to Tessa, her use of culturally relevant examples helped her students make personal connections to the material by prompting discussions on moose hunting and linking it to the structure and function of the mammalian respiratory system. Tessa also shared her experience with teaching ecology using local ecological systems found among her students' rural communities. In her words, "Whenever we discuss ecology…I try to use examples that are local to my students. When we are talking about trophic levels and energy pyramids, for example, we are talking about caplin and the cod fish." In Tessa's words, "Using relevant and local content with local examples and anecdotes whenever I can, is important to my teaching."

Tessa reflected on her use of culturally relevant subject matter and how it relates to socio-scientific issues. In her words, “I think it is an important thing to focus on in science [socio-scientific issues]—to understand that connection between science and society. It is much more important in my opinion, than discrete science outcomes”. She proceeded with sharing an example, “To make [climate change] culturally relevant to NL, we talk about food security; we look at grocery prices in Labrador, and we look at how shelves are empty when there's a storm coming.” Tessa also raised the issue of how “sometimes local knowledge is dismissed over more Western academic science”, and how “that’s not appropriate when there are various Ways of Knowing science.” Tessa described how she confronts this dismissal of local knowledge by “validating [other] life experiences” in her teachings. She explained:

> We talk about local knowledge acquired over generations, particularly Indigenous ecological knowledge. We talk about the value of that form of science. We take the opportunity to validate weather lore, and the legitimate perspectives that are very valuable. I think that opens the door for Indigenous peoples] to feel more comfortable contributing, by giving those anecdotes, and including their experiences and culture in the curriculum. It gives them more opportunity to feel like they can bring ideas forward.

Tessa expressed that she would like to welcome community members, parents, guardians, and elders into her distance science classrooms to discuss their life experiences in relation to the curriculum science topics, but she had not yet had the opportunity.

River also discussed her use of local scientific knowledge using folklore and NL expressions in teaching science. In the weather unit of the Science 1206 course, River assigns her students the task of finding folklore and NL expressions that are related to weather and exploring the science behind them. According to River, her students often reach out to their elders and family members for help. River claimed, “Many students will go to their elders or family members, such as their grandparents, or family friends.” She continued, “I had one kid who got his expression from his grandfather. It was really moving to hear him describe his interaction with his grandfather, it was sweet…It was a great opportunity to bring culture to science.” River explained that many of her students are from fishing communities that have “expressions for weather, as weather affects their day-to-day business” and that her students were “able to research the science behind it, and there was real science behind a lot of it.”

4.3 Distance Science Educators’ Challenges with Implementing CRST

All five teacher participants unveiled challenges with implementing CRST by distance. The challenges presented by the teacher participants were coded into two themes (i) limitations due to lack of physicality, and (ii) curriculum and pedagogical constraints. For the purposes of this study, physicality is defined as the teacher being physically present with the students in a single teaching and learning environment. This study refers to curriculum constraints as the circumstances within the curriculum design that constitute barriers for teachers to implement CRST in their teaching practices by distance. Pedagogical constraints refer to the limitations experienced by teachers in practicing CRST due to the lack of familiarity with the theory.

4.3.1 Lack of physicality

All five teacher participants discussed the lack of physicality as a challenge to incorporating CRST in the distance classroom for two principal reasons (i) the challenge of building a safe space for students through communication by distance and (ii) the difficulties of executing scientific place-based and hands-on activities that are culturally relevant by distance. According to the teacher participants, building a positive and inclusive classroom dynamic can be challenging from a distance perspective. With communication being an important affordance to CRST practice, challenges with communicating by distance had shown to inherently cause challenges in providing an inclusive environment where students feel comfortable to share about themselves and participate in science. Various obstacles presented themselves in the teacher participant responses as unique to distance educators, making it more challenging to implement CRST in the virtual classroom.

Challenge of Building a Safe Space for Students through Communication by Distance. In distance education, communication is strictly confined to the internet. When internet connectivity is poor or absent it becomes problematic for teachers and students as they rely on the internet for instruction. Internet connection is a concern for many remote students due to location, local weather, and the internet bandwidth. According to the teacher participants, students struggle to remain focused and often disengage from a lesson when the internet connectivity is inconsistent. In River's words, "What will happen is that you lose the kids." River attributes losing the kids as losing the students' attention and focus. In addition to internet connectivity, communication is challenged due to not being able to see the students. River explained that cameras were not often used because of poor internet connectivity and the fact "a lot of the kids come from very small communities, and it is their first time doing a course online, so they are often not comfortable turning on their cameras." Lily explained that not being able to see the students is challenging because she is not able to "read the room." In Lily's words, "I do not know what my students are doing behind the screen. I cannot read their faces, their expressions, or see their gestures."

Connecting to students by distance was demonstrated to be difficult, requiring more creative and diverse methods by the teacher participants to achieve the affordance of communication and inclusion. Lily described the effect distance learning can have on students who are not as vocal or engaged by distance. According to Lily, "If [the student] is sitting there quietly online, sometimes that student is absolutely acing the course but sometimes that student is so lost that they do not even know where to start asking questions." Lily continued to explain how quiet students in distance classrooms may be more likely to "slip a little behind in the course because [the teacher] cannot walk around and check their work." Lily explained how keeping track of the students, by making sure that everyone is where they need to be, is challenging online. Shawn expressed similar feelings about the lack of physicality and its effect on communication. He reflected:

> I noticed [the students] were not so quick to answer my questions. They were a little bit on the shy side…When you are physically present with the students, there is a wider tapestry of cues available to you. I can circle around and have a look at what they are doing. Even subtly, I can glance around…I cannot do that in a distance classroom. So, I am a little more hamstrung than I would be [in person].

When communication is challenging, it becomes more challenging to create a safe space for students to share details about themselves and their needs, an important affordance of CRST. Lily spoke on the lack of physicality and its effect on communication regarding students who struggle with English as an alternate language (EAL). Lily explained how students who struggle to understand and speak English are faced with additional obstacles when learning online, as compared to their peers whose English is their first language. Distance teachers face additional obstacles regarding connecting to EAL students and providing for their individual needs by distance. In Lily's words, "There is definitely gaps in terms of making things inclusive and accessible for everyone [virtually]." Lily provided an example:

> I felt that the student was capable of the physics, but being online, language was a barrier. I tried to connect through email to provide extra help although the English was very broken; it was difficult to provide quality assistance…The PASS teacher at the school tried to connect with the student to see what they could do to help, but unfortunately the content seemed to move so fast that that student could not keep up.

According to Lily, connecting with all students online can be challenging, but ensuring that the EAL and exchange students are comfortable and able to share appeared to be further challenging. Lily said, "I try to reach out to the [exchange students] to see how it is going in their placements/where they are living…I want to know how things are going, how they are feeling, if they are adjusting to the online environment, etc." Lily's attempts at connecting with her exchange students through communication by distance was a challenge but vital to CRST as it is meant to help promote a safe space for them to share, and for Lily to learn about her students' cultures and lifestyles.

Differences in cultures are not always obvious among the distance learners. River explained, "[The distance learners] do not all come from the same culture, and they do not all have the same [life] experiences." River expressed how a classroom of distance students can have immense differences in cultures despite most students being from NL. River explained how culturally relevant science topics may not resonate with some students as not all students are culturally homogenous, posing another challenge in implementing CRST. It was evident through the teacher participant responses that a deeper understanding of the cultural commonalities, and the cultural differences between students must be formed to practice CRST, though the challenge of communication by distance poses a challenge to becoming informed of the various student cultural identities.

Communication has shown to be a challenge between the distance classroom teachers and their students, requiring much more effort on behalf of the teacher to ensure a positive classroom dynamic where students feel comfortable enough to share and engage in classroom lessons. According to Shawn, there is an added challenge for distance educators to portray one's demeanor *online* in an effective manner as communication styles are more easily misconstrued online than they are face-to-face. Shawn explained how tact and kindness must be emphasized by the classroom teacher in the online setting. He explained:

> A teacher who drops sarcasm and is a little aloof can probably make it in a face-to-face classroom, but it is not going to fly online. The students will just shut down because they do not have any other information on [the teacher] …Online, all that [the students] see is the sarcasm and the aloofness.

Tessa described the challenge of being online as a barrier for students to communicate with each other. In her words, "It takes longer for relationships to forge between students, and for them to be able to engage in discussions or conversations together—to get to that level of comfort with one another."

Among the teacher participant responses, communication demonstrated to be a challenge in incorporating CRST due to lack of physicality. Online barriers in communication due to lack of physicality made it difficult for teachers to be responsive to their students' needs, and to recognize and learn the various cultures within the student body. With the challenge of effective and responsive communication, the teacher participants found it difficult to create a safe space online to share and engage—an affordance of CRST.

Challenges of Implementing CRST through Experiential Learning by Distance. Lack of physicality was also deemed challenging by the teacher participants when implementing scientific laboratories and outdoor activities by distance and making them culturally relevant. According to Louis,

> The fact that we are teaching online, there is an added challenge [in teaching science]. Science courses should be more outdoor or lab-based, having their hands involved somehow…I think there is not enough room for kids to fully explore [online]. It is more like "you need to know this piece of knowledge, and whether you can do something with it or not, it doesn't matter", hence there is no value to it.

Louis stated that "the kids are going to develop better critical thinking skills if they can explore." Extending the value of hands-on activities to include something meaningful to the students' cultures and rural identities is an added challenge for teacher participants due to the circumstances of not being physically present. In Tessa's words,

> So much of NL culture is based on the land, and being able to go outside with kids is a luxury we do not always have [as distance educators]. It would be wonderful if we were able to bring [all the distance learning students] to a place where they can engage in exploring both traditional ecological knowledge alongside of Western science within the NL ecosystem—that would be beautiful.

Tessa described the "physical barrier" of being online as "most challenging" when incorporating CRST into field activities when learning science. She reflected:

> I have friends who teach in small communities where they can take their students out fishing and engage with the land. I think that is amazing, but I do not know how that would happen within our [online] setting, even if we had supports available to facilitate something like that, it is much more difficult with the various [locations] and schools involved.

The core curriculum laboratory exercises present unique challenges for distance educators. These laboratories are often not culturally relevant, and the participant teachers have demonstrated that their focus had been on navigating the challenges based on the lack of conventional laboratory resources without the added challenge of including resources that are culturally relevant. Tessa described, “Labs have been very challenging. A lot of the schools that my students attend do not have the [lab] supplies, they do not have someone to acquire [the supplies] or have someone supervise the student while they do their labs.” According to Lily, “Lab gear tends to get damaged or go missing…someone is in a rush, they do not pack it away properly, and then the next group goes to look for it, and it is not where it is supposed to be.” Lily also described her biggest challenge as not being able to see her students during a laboratory exercise. She expressed, “I can only hope and trust that they are doing what they are supposed to be doing.” Lily and Shawn reflected on virtual laboratories as an asset to distance learners in physics, although both teacher participants discussed virtual labs as an additional tool rather than an alternative to hand-on laboratories. Lily elaborated, “Many of our labs can be done virtually. Although, it is not giving them the hands-on tangible experience that often solidifies a subject for them”. According to the participant teachers, there is little to no room to make the virtual laboratories culturally relevant as they are not usually designed by the classroom teacher (e.g., PhET), and the initial challenge of providing the minimum resources needed for the hands-on laboratories to occur had shown to take precedence over practicing CRST within the scope of these exercises.

4.3.2 Curriculum and Pedagogical Constraints

The teacher participants presented curriculum and pedagogical constraints as impediments to implementing CRST. Examples of curriculum constraints provided by the teacher participants included (i) curriculum content with time as a limitation, (ii) the lack of resources on CRST for distance educators, and (iii) the lack of Indigenous scientific knowledge within the curriculum guides. Pedagogical constraints included the unfamiliarity with the concept *CRST* by the teacher participants primarily due to (i) the lack of reference to CRST in the science curriculum guides, and (ii) the lack of professional learning opportunities in their teaching careers.

Curriculum content presented as a concern for all teacher participants in their science teachable areas: general science, environmental science, earth systems, biology, chemistry, and physics. All five teacher participants attributed the quantity of discrete curricular outcomes as a constraint to implementing what they considered to be CRST. According to Lily, "The [science] curriculum is jam packed and very regimented." All teacher participants shared the same concern and voiced their opinions on the science curriculums' restrictive nature. River disclosed a passion for incorporating CRST using projects. Although ardent about culturally relevant science projects, River expressed concerns with the practicality of doing science projects with the demand of her science course content. In her words, "There is too much content [in the curriculum guides]…when you are factoring in the time to cover all the content, time to do projects or giving students time to work on projects is *not* factored in." Shawn shared similar thoughts on the science curriculum guides as a constraint to CRST. According to Shawn, CRST is a cultural adaptation to the needs of his students, although the curriculum guides are too prescriptive to fully embrace this practice. Shawn voiced:

> The last few [curriculum] guides I have picked up were not *guides*; *guide* means that the goal post is *this* wide [armlength motion] and it describes what is between those wide goal posts. The last time I picked up a curriculum guide, the goal posts had shrunk. They

are about *this* wide now [motion a short distance between hands]. [The guides] were too prescriptive to allow me to adapt to the needs of all my learners.

Tessa's response included her concerns regarding the constraint that discrete outcomes can have on CRST. She said:

A lot of the [science] curriculum focuses on smaller, more discrete outcomes, rather than the bigger picture. If the [science] curriculum were to focus more on the big picture or making connections, there would be more time available to explore the relevance of the curriculum to [students'] cultures, and socio-scientific issues.

Louis shared his thoughts on the magnitude of content in the science curriculums as well. He voiced, "If we had a little bit of freedom [in the curriculum guide], I think there is a lot of great things that could happen, but we are sort of in this little box that has no flexibility." Lily's similar thoughts focused on the lack of autonomy teachers have in the science curriculum guides, and its' impact on including activities that may be considered culturally responsive. She said, "It does bother me—the lack of autonomy, the lack of ability to build [activities involving community], which are important in so many ways, with components that are cross-curricular, and/or pertaining to life."

When introduced to the study, all five teacher participants were transparent in unveiling their unfamiliarity with the terminology CRST, although they formed meaning from the term and shared personal experiences that they considered to be applicable. It was demonstrated by the teacher participants' responses that their lack of knowledge of CRST is primarily attributed to the lack of reference to CRST in the science curriculum guides, and the lack of professional development on CRST. The teacher participants lacked prior exposure to CRST, and with it, the absence of available and accessible resources, posing an impediment to implementing CRST.

Louis discussed the challenge of having limited resources cultivated for distance educators who wish to practice CRST. Louis reflected:

> I do not think that our [science curriculums] are giving us any kind of tools to develop, help, or promote this kind of thing [areas to explore cultural relevance and rurality regarding students' interests]. It is the individual teachers that come up with those ideas and push it forward to make it happen.

Similar thoughts presented in Tessa's response. According to Tessa, "It is really important to have professional development geared toward [distance education and CRST]: how to do it, and what resources are available." She continued, "Biology and ecology lend themselves to having more opportunities to make cultural and place-based connections, but I think it could be spelled out more in the curriculum." In addition to making cultural and place-based connections, Lily expressed the need for the science curriculum guides to incorporate "opportunities to bring forward Indigenous ecological knowledge." The lack of exposure to Indigenous scientific knowledge poses an impediment to practicing CRST. Tessa described an additional challenge to incorporating Indigenous scientific knowledge in CRST, is the lack of support and validation presented in the science curriculum guides. According to Tessa, without this provision, many teachers "would *not* be inclined to validate traditional knowledge as true scientific knowledge…" In Tessa's words,

> There is a perception of Western science as being superior, and I do not think that the curriculum does anything to address that. If it did, it would help students feel more valued, and more part of the curriculum. I think that having a science curriculum that acknowledges the contributions of [Indigenous] communities, like incorporating

traditional ecological knowledge, would help build bridges between communities, and improve [Indigenous] students' self-esteem, and self-perception.

Tessa attributed the "lack of validating traditional scientific knowledge" to "the [science] curriculum, and to the lack of professional development."

Common challenges with implementing CRST by distance presented themselves as curriculum and pedagogical constraints. Despite the shared challenges, all teacher participants were able to provide their own understands and examples of CRST by distance. It became evident that shared characteristics among all five teacher participants afforded them the ability to practice CRST without a fundamental knowledge of the terminology, and the realization of its importance: the manifestation of critical consciousness and DCE, which will be further explored in the following section (discussion, conclusions, and implications).

Chapter 5: Discussion, Conclusions, and Implications

The purpose of this research study was to explore how NL science teachers are incorporating CRST in their teaching practices by distance. The conceptualization and design for this research was guided by the questions: (1) How are distance educators making science culturally relevant for students regarding their rural homelands, and community cultural identities? (2) What challenges do distance science educators face with implementing CRST in the virtual classroom? In this section, the results will be discussed in the context of existing literature on CRT and CRST, followed by the formation of a grounded theory that uncovers a framework for CRST for distance science education.

5.1 Grounding Distance Science Educators Views of CRST within Existing Theory

The findings showed that the teacher participants were not acquainted with the exiting terms CRST, CRT, and CRRP, however, they shared their own conceptualizations of cultural relevance by using terminology they were familiar with. The terminologies used by the teacher participants to conceptualize CRST were discussed in terms of (i) authentic education and, (ii) differentiated instruction with attention to (a) individualizing the curriculum, (b) experiential learning, and (c) place-based education. In the following section, these terms have been discussed to ground the teacher participants' understanding within the broader framework of CRST.

5.1.1 Grounding Authentic Education within DCE and CRST

The teacher participants used the term authentic education when describing their understandings of CRST, or when sharing examples of their CRST practices by distance. This section will summarize the authentic education movement toward DCE and its relation to contemporary literature on CRT and CRST. Authentic education, according to Sarid (2014), “aims to encourage the personal development of individuals to shape their own identity according to their own interests, preferences, and capabilities as well as to express their own unique and irreplaceable individuality within learning processes (p. 474).

The theory of authentic education surfaced when schooling began to transition away from a standardized, factory model of education toward a model of DCE. CRT (and CRST) can be difficult to envision within standardized education values where “curriculum sees the nation as one, and all students, and all places, as having the same needs in terms of knowledge” (Roberts, 2017, p. 15). Authentic education includes personalizing learning tactics and finding ways to incorporate students’ own experiences in science lessons (Davis et al., 2015). The DCE movement, which involves the collective process and addressing cultural inequities, expands on the authentic education model by including social justice and democracy in the classroom—essential groundwork for CRT and CRST. Mackenzie (2021) found that DCE can aid in the framework of CRT when being responsive to culture in science education, ultimately bridging classrooms and communities. The acknowledgment and respect for different cultures and identities that supply a classroom is a practice of critical consciousness, a pillar of the CRT model by Ladson-Billings (1995) and conscientization, a term used to describe a social concept in DCE, grounded in Marxist critical theory (Davis et al., 2015). Critical consciousness and conscientization are similar terminologies used by educators to identify the antiquated values that sustain the marginalization of specific groups of people within the hidden curriculum (the norms, values, and beliefs that are implicitly taught). According to the research findings of this study, the teacher participants demonstrated DCE by safeguarding the democratic rights of their students to prevent marginalization. Their values reflected critical consciousness and conscientization by acknowledging, respecting, and applying the differing worldviews, cultures, and identities of their students to science lessons, establishing the use of CRST within their teaching practices by distance.

5.1.2 Grounding Differentiated Instruction within CRST

All five teacher participants in this study were employed by NL Schools and followed the NL public school science curriculum guides to instruct their science courses by distance. The teacher participants did not receive any professional learning opportunities on CRT or CRST in their teaching careers, although they associated the terminologies CRT and CRST with concepts they were familiar with including: (i) individualization, (ii) experiential learning, and (iii) place-based education. This section will discuss these terminologies within the context of differentiated instruction with relevance to CRST.

The terminologies used by the teacher participants to describe CRST (i) individualizing the curriculum, (ii) experiential learning, and (iii) place-based education can be visualized in the context of differentiated instruction present within CRST frameworks in published works, as well as the NL science curriculum guides. Differentiated instruction presents itself as a theme within the CRST framework proposed by Barron et al. (2021). According to Barron et al. (2021), differentiated instruction in the context of CRST is achieved by teachers who intentionally change their instructional approach to "decolonize classrooms such that students and community members exercise sovereignty, self-determination, and cultural and linguistic repossession" (p. 1323). Differentiated instruction is outlined in the NL science curriculum guides as "a teaching philosophy based on the premise that teachers should adapt instruction to student differences. Rather than marching students through the curriculum lockstep, teachers should modify their instruction to meet students' varying readiness levels, learning preferences, and interests"

(Science 1206 Curriculum Guide, 2018, p. 5). The NL science curriculum guides discuss the importance of using differentiated instructional practices to provide all students with "a safe and supportive place to learn and succeed" (Science 1206 Curriculum Guide, 2018, p. 5). The science curriculum guides' framework for differentiated instruction includes six components: (i) planning for differentiation, (ii) differentiating the content, (iii) differentiating the process, (iv) differentiating the product, and (v) differentiating the learning environment. The teacher participants' use of individualization to describe CRST can be recognized in the NL science curriculum guide's definition of differentiating the content; (ii) the teacher participants' use of experiential learning to describe CRST can be recognized in the NL science curriculum guide's definition of differentiating the process; and (iii) the teacher participants' use of place-based education to describe CRST can be recognized in the NL science curriculum guide's definition of differentiating the learning environment.

Differentiating the content involves creating opportunities for enrichment or more in-depth consideration of a topic of particular interest (Science 1206 Curriculum Guide, 2018). Likewise, the proposed terminology by the teacher participants for describing CRST, individualization, is "a process of planning and implementing learning experiences that are responsive to each child's interests, strengths, and needs" (ECLKC, 2020). The model of CRST proposed by Iet al. (2013) includes three components that align with differentiating the content, and individualization: (i) content integration (inclusion of content from other cultures), (ii) facilitating knowledge (building on what the students know), using "real world" examples, and (iii) academic development (the use of instructional strategies that reflect the needs of diverse backgrounds and learning styles).

Differentiating the process involves "varying learning activities or strategies to provide appropriate methods for students to explore and make sense of concepts" (Science 1206 Curriculum Guide, 2018, p. 6). Experiential learning, the terminology proposed by the teacher participants to describe CRST, is described by the educational theorist David A. Kolb through his working definition of learning: "the process whereby knowledge is created through the transformation of experience" (1984, p. 38) and demonstrated using his model of experiential learning involving the cyclic process of (i) concrete experience, (ii) reflective observation, (iii) abstract conceptualization, and (iv) active experimentation (1984). According to Kolb (1984), the learner first encounters an experience in the light of new concepts (concrete experience) followed by a reflection on the experience in the light of their existing knowledge (reflective observation), giving rise to a new idea or modification of an existing concept (abstract conceptualization) and applying the new idea to the world around them to visualize the outcome (active experimentation). The themes outlined by Stephens (2000) in the "Handbook for Culturally Responsive Science Curriculum" are prospects for experiential learning, and fundamental concepts in differentiating the process of learning science when implementing CRST. Stephens (2000) describes the integration of both traditional Indigenous knowledge and Western science in science curricula by emphasizing commonalities including: (i) organizing principles (e.g., body of knowledge is stable but subject to change), (ii) habits of mind (e.g., honesty, inquisitiveness), (iii) skills and procedures (e.g., empirical observation in natural settings), and (iv) knowledge (e.g., plant and animal behaviour, cycles, habitat needs, interdependence).

Differentiating the learning environment involves structuring the physical learning environment "in such a way that all students can gain access to information and develop confidence and competence" (Science 1206 Curriculum Guide, 2018, p. 7). Place-based education, proposed by the teacher participants as CRST practice, represents differentiating the learning environment by incorporating the pedagogy of community, the reintegration of the individual into their home ground, and the restoration of the essential links between a person and their place (Sobel, 2004). Ark et al. (2020) describe place-based education using six design principles: (i) Community as Classroom, (ii) Learner-Centered, (iii) Inquiry-Based, (iv) Local to Global, (v) Design Thinking, and (vi) Interdisciplinary. The six design principles are closely linked to existing CRT and CRST frameworks (for example, frameworks by Cooper & Mathews, 2005, Kopkowsji, 2006, and Barron et al., 2021). Ark et al. (2020) describe the first design principal, "Community as Classroom" where "communities serve as learning ecosystems for schools where local and regional experts, experiences, and places are part of the expanded definition of classroom" (p. 104). Within the context of community and CRST, Cooper and Matthews (2005) claim "science teachers must become acquainted with their students, especially within the communities in which they live. By doing so, science becomes a contextualized engagement and a culturally relevant experience" (p. 52). The second design principal by Ark et al. (2020), "Learner Centered" ensures "learning is personally relevant to students and enables student agency" (p. 104) and the last design principle, "Interdisciplinary", values the curriculum connection to the real world, where "traditional subject area content, skills, and dispositions [are] taught through an integrated, interdisciplinary, and frequently project-based approach in which all learners are accountable and challenged (104). Similarly, Kopkowsji (2006) describes CRT as "understanding students' home life, language, music, dress…[and] the role of religion and community in their lives...It is bringing the experiences of their 24-hour-day into the seven-hour school day to give them information in a familiar context" (p. 1). Barron et al. (2021) uses "relevancy to students' lives" as a theme in their CRST framework to link science content with students' skills, talents, and household knowledge and practices gained from within their homes and communities.

5.2 Grounding Science Educators' Practice of Cultural Relevance within CRT and CRST Frameworks

The findings showed that an analysis of the science teaching practice of cultural relevance in the online setting led to the emergence of unique themes. First Theme-was 'affordances' that included (a) the creation of a safe space for student voice through communication by distance and (b) the creation of a safe space by respecting student cultures and rural identities by recognizing and celebrating the differences among students**,** honoring students' local dialects**,** and ensuring that the students' cultures and rural identities are represented in science. The second theme was 'applications' that*,* included the practice of implementing CRST by distance: culturally relevant project-based learning and culturally relevant subject matter. In the following sections, these emerging themes have been discussed in context of existing CRST frameworks and principles.

5.2.1 Grounding Affordances: The Precursor to CRST Application by Distance

This category was deemed an essential precursor to CRST application as designs for culturally responsive science projects and subject matter must be developed after learning students' cultural backgrounds and rural identities through authentic means (e.g., by getting to know the students and their communities through interaction) . The description of CRT by Kopkowsji (2006) involves "understanding students' home life, language, music, dress…[and] the role of religion and community in their lives..." (p. 1) which emphasizes the need for learning students' cultures and lifestyles. The teacher participants discussed ways they come to understand their students' cultures and rural identities through online communication by utilizing technology in various ways to promote a safe and inclusive online environment. According to Barron et al. (2021), CRST is described as a powerful pedagogical tool that incorporates student interaction within its framework, where students should have the opportunity to talk about their cultures and express themselves without judgment. The review of multicultural science education by Cooper and Matthews (2005), emphasized the need for:

> Science teachers [to] become acquainted with their students, especially within the communities in which they live. By doing so, science becomes a contextualized engagement and a culturally relevant experience, one that allows students to link their daily experiences to what they do in class (p. 52).

The teacher participants in this study became acquainted with their students by promoting a safe space for students to discuss their interests and lifestyles through digital forums, informal discussions during online sessions, and direct messaging in the virtual classroom setting, ultimately building trust and respect between the teacher and the students.

The teacher participants demonstrated respect for student cultures and rural identities, the second provision of affordances, by recognizing and celebrating the differences among students, honoring students' local dialects, and ensuring students' cultures and rural identities are represented in science, all of which is meant create a safe space for students in the online classroom setting. Three pillars presented in the CRST model proposed by Hernandez et al. (2013) align with this category of research findings: (i) prejudice reduction, (ii) social justice, and (iii) academic development. Hernandez et al. (2013) defined "prejudice reduction" as the use of native language support, positive student-centered interactions, and a safe learning environment. This pillar aligns with the need for creating a safe space, and more specifically, honoring of students' local dialects. "Social justice" is defined by the teacher's willingness to act as agents of change, and the encouragement of question-posing and challenging the status quo in order to aid in the development of sociopolitical or critical consciousness accomplished through modeling, and "academic development" is the teacher's ability to create opportunities to aid all students in their development as learners to achieve academic success, and the use of research-based instructional strategies that reflect the needs of diverse backgrounds and learning styles (Hernandez et al., 2013). These three pillars (prejudice reduction, social justice, and academic development) can be represented by ensuring that students' cultures and rural identities are represented in science. Respect for students' cultures and rural identities is ultimately meant to create a safe space for students to comfortably represent themselves in their distance science classrooms; in doing so, teachers have the affordance of learning about their students and therefore can apply authentic and respectful CRST materials in their lessons.

5.2.2 Grounding Application: The Practice of CRST by Distance Educators

Findings showed that the teacher participants were able to apply the practice of CRST in the context of distance science education through (i) Culturally Relevant Project-Based Learning (CRPBL) and (ii) Culturally Relevant Subject Matter (CRSM). These two themes are grounded in the framework proposed by Avery and Hains (2017) in recognizing rurality in science education. The framework by Avery and Hains (2017) involves three pillars:

> (i) Connecting science education to students' sense of 'place' as physical, historical, and sociocultural dimensions in their community, (ii) Applying students' 'funds of knowledge' and cultural practices, [and] (iii) Using project-based science learning centered on authentic questions and activities that matter to students (p. 162).

CRPBL pertains to connecting science to students' sense of physical 'place', as well as the other characteristics of recognizing rurality in science education proposed by Avery and Hains (2017): the "historical and sociocultural dimensions", making lessons place-based *and* culturally relevant. An adaptation of CRPBL to the online setting was realized in the practice of CRST by the teacher participants by integrating elements of community involvement, local scientific knowledge, and relevant socio-scientific issues with scientific outcomes in the form of place-based projects. These culturally relevant place-based science projects were mostly student-led and included investigations of scientific phenomenon present within the students' individual lives, or communities.

Three design principles of place-based education by Ark et al. (2020): (i) Inquiry-Based, (ii) Local to Global, and (iii) Design Thinking, align with CRPBL. The "Inquiry-Based" learning principle is "grounded in observing, asking relevant questions, making predictions, and collecting data to understand the economic, ecological, and sociopolitical world" (Ark et al., 2020, p. 104). This principle aligns with the inquiry-based aspect of CRPBL as projects are often student-proposed and student-led investigations involving collecting data of this nature. The "Local to Global" principle "serves as a model for understanding global challenges, opportunities, and connections" (Ark et al., 2020, p. 104). This principal aligns with CRPBL as the cultural and place-based aspects of the projects often have global connections. The "Design Thinking" principle "provides a systemic approach for students to make a meaningful impact in communities through the curriculum" (Ark et al., 2020, p. 104). This principle aligns with CRPBL as many of the projects discussed by the teacher participants had meaningful impacts in the communities from which the students reside.

The second application of CRST by the teacher participants included CRSM by using examples that were tailored to make the content of their science lessons more relatable to their students' lives. CRSM aligns with the second pillar of the framework proposed by Avery and Hains (2017) in recognizing rurality in science education: "Applying students' 'funds of knowledge' and cultural practices" (p.162). CRSM involves applying students' funds of knowledge—a practice observed in the teacher participant examples of CRST. In addition to the previously discussed pillars of CRST proposed by Hernandez et al. (2013) (prejudice reduction, social justice, and academic development), the remaining pillars include (iv) content integration, and (v) facilitating knowledge construction, which align with CRSM. Hernandez et al. (2013) define "Content Integration" as "the inclusion of content from many cultures, the fostering of positive teacher-student relationships, and holding high expectations for all students" (p. 810). Hernandez et al. (2013) define "Facilitating Knowledge" as the process of "building on what the students know, using 'real world' examples, and assisting students in learning to be critical, independent thinkers who are open to other Ways of Knowing" (p. 810). The inclusion of cultural content, and building on what students know, using 'real world' examples, are fundamental aspects to CRSM. Stephens (2000) also aligns with CRSM through its' description of important factors in culturally responsive science curricula, including:

> (i) Cultural significance, involving local experts; (ii) linking science instruction to locally identified topics, and to science standards, providing ample opportunity for students to develop a deeper understanding of culturally significant knowledge linked to science; (iii) teaching practices that are compatible with the cultural context; and (iv) engaging ongoing authentic assessment, guiding instruction with deeper cultural and scientific understanding, and reasoning and skill development tied to standards (p. 7).

Stephens (2000) claims “the work of creating a culturally responsive science curriculum is context specific, dynamic and ultimately reflective of what one believes, values and thinks worth knowing” (p. 10). Among the examples provided by teacher participants that pertain to CRSM, various Ways of Knowing science appeared as a valuable component of teaching science and therefore became an important component of CRSM. Stephens (2000) describes the integration of traditional Native knowledge and Western science, with emphasis on a common ground between the two: organizing principles (e.g., body of knowledge is stable but subject to change), habits of mind (e.g., honesty, inquisitiveness), skills and procedures (e.g., empirical observation in natural settings), and knowledge (e.g., plant and animal behaviour, cycles, habitat needs, interdependence). Stephens (2000) claims that the application of knowledge is of paramount importance and should be the forefront of topic selection, with the local environment, and seasonal appropriateness in mind. Application of knowledge appears in CRSM with the use of local scientific knowledge using folklore and local expressions in teaching science, as well as including and validating Indigenous Knowledge Systems (IKS). According to Aikenhead and Ogawa (2007), IKS may be described as (but not limited to) traditional knowledge, traditional wisdom, traditional ecological knowledge, Native science, Aboriginal science, Ma ̈ori science, and Yupiaq science. Aikenhead and Ogawa (2007, p. 553) describe IKS as:

> The process of generating or learning Indigenous ways of living in nature by Coming to Know or Coming to Knowing [phrases that connote a journey]. Coming to Know differs from the Eurocentric science process to know (i.e., to discover) that connotes a destination, such as a patent or a published record of a discovery. An Indigenous Coming to now is a journey toward wisdom or a journey in wisdom-in-action, not a destination of discovering knowledge.

The inclusion of IKS in CRSM is an essential part of CRST in distance science education; this integral part of the framework is not based solely on the presence of Indigenous students in distance science classrooms but is mainly based on the fact it should be included in all science curricula, and to be used by all science educators because science for all should not be limited to Western ways of teaching and learning.

5.3 Grounding Challenges with Implementing CRST by Distance: A Comparison with Literature

Findings showed that the participant distance science educators faced several challenges in implementing CRST that included (i) lack of physicality and (ii) curriculum and pedagogical constraints. This section will explore the challenges experienced by the teacher participants in this study and how they relate to those experienced in other research studies involving CRT, CRST and distance science education.

5.3.1 Grounding Lack of Physicality

Lacking a physical presence presented as a challenge for distance educators in implementing CRST. A physical classroom is a valuable resource for teachers to use in communicating with their students and observing their students' behaviours in a safe and inclusive way. As students merge from diverse, rural communities for synchronous online lessons, distance educators lack the affordance of being near their students and must navigate online platforms to find innovative ways to create a safe space for their students to communicate. This challenge presented with the increased cognitive load to learn and apply novel methods of communication with the purpose of acquiring familiarity with students' cultures and rural identities to implement CRST. Rodriguez (2013) claims teacher uncertainty with drawing on funds of knowledge presents as a challenge, which is emphasized in the online setting.

Challenges with teaching online, not specific to CRST, are common (i.e., Artze-Vega & Delgado, 2019; Nilson & Goodson, 2018). These challenges include "[educators'] familiarity with/preference for face-to-face teaching; their limited technological abilities and busy schedules; the relative absence of experienced online faculty to serve as opinion leaders and role models; and [educators'] attitudinal beliefs about technologies" (Artze-Vega & Delgado, 2019, p. 27). Nilson and Goodson (2018) identified challenges with teaching online with a focus on disincentives: (i) lack of institutional support and rewards, (ii) unreliable technology, (iii) absent or poor technical support, (iv) absent or inadequate training, (v) concerns about workload, and (vi) concerns regarding quality. According to Nilson and Goodson (2018) these disincentives manifest as disengagement and/or resistance to online teaching and related professional development. In accordance with findings from Nilson and Goodson (2018), the teacher participants in this study discussed difficulties with unreliable technology from an internet connection standpoint—this factor is a reality for students located in rural areas where internet connection is compromised, ultimately impacting student-engagement.

Limited resources for distance educators presented as a challenge by the teacher participants in this study. The inability to host a lesson in-person with access to physical resources such as those found in a laboratory, or outdoors for an experiential learning opportunity, is not lost, but presented itself as more challenging in the online setting. This challenge includes the need for additional and alternative teacher supervision with access to equipment in various locations. It requires additional creativity, and determination by distance educators to pursue such endeavors with the added component of CRST.

5.3.2 Grounding Curriculum and Pedagogical Constraints

In addition to the limited physical resources, or challenges with accessing them, curriculum and pedagogical constraints included (i) volume of curriculum content with time as a limitation, (ii) lack of resources on CRST for distance science educators, (iii) lack of material on Indigenous scientific knowledge within the curriculum guides, (iv) lack of reference to CRST in the science curriculum guides, and (v) lack of professional learning opportunities for distance science educators on CRT and/or CRST. Ambrose et al. (2010) identified three challenges with implementing CRT in the online setting: (i) perception of value, (ii) self-efficacy, and (iii) a supportive environment. The participant teachers in this study differed in their perception of value from those claimed by Ambrose et al. (2010) as the participants discussed their admiration for the practice of CRST, however, they shared the challenge of insufficient faculty supports. The teacher participants' challenges pertaining to curriculum and pedagogical constraints align with the three barriers to instructional designers' cultural responsiveness by Rogers et al. (2007) including: (i) an overemphasis on content development as the center of practice and under-emphasis on context and learner experience, (ii) a relative lack of evaluation in real-world practice, and (iii) the creation of less-than-ideal roles that instructional designers assume in the larger organizational structures involved (p. 207). Similarly, Barron et al. (2021) considered limited autonomy in curriculum design/implementation as a challenge, also aligning with the curriculum and pedagogical constraints in this study.

5.3.3 Grounding Suggestions for Overcoming Challenges

Artze-Vega and Delgado (2019) proposed ways to overcome challenges with implementing CRT in distance education by encouraging influential developers (e.g. administrators or curriculum developers) to "help [educators] see the purpose and value of online learning, culturally responsive teaching, and culturally responsive online teaching” (p. 30). Artze-Vega and Delgado also suggest the developers “help [educators] gain confidence in their technological skills, and in their ability to teach online and in culturally responsive ways” (p. 30) as well as “exhibit the same care and cultural responsiveness [that] [educators] are encouraged to employ in their teaching, making it safe for [educators] to make mistakes and promoting collaboration among [them]” (p. 30). In addition to the proposed challenges by Artze-Vega and Delgado (2019), an increased exposure of CRST in science curriculum guides with access to online resources, and PL opportunities may help overcome curriculum and pedagogical constraints. Innovative technological advances in online teaching platforms may also assist in the quality and delivery of lessons to rural areas, by distance.

5.4 Conclusion

The purpose of this study was to explore how NL science teachers perceive and incorporate CRST in their science teaching practices by distance. As we shift away from standardized education toward DCE, there is a growing and belated need to develop CRST practices in education by making connections between what is being taught in classrooms to student cultures and rural identities. This study was intended to explore current practices of CRST in distance science education classrooms. The research questions were answered using a qualitative research methodology through a grounded theory approach with semi-structured interviews for data collection. This section will discuss the common themes which emerged through the inductive analysis to support a growing framework for CRST, providing a guideline to help science teachers adapt their CRST practices and inform pre-service science teacher education.

5.4.1 Development of a CRST Framework for Distance Science Education

Taking into consideration the discussion and applying grounded theory, a framework for CRST in distance science education was conceived (Figure 1). The process of understanding CRST in the context of distance education began with asking relevant research questions to gather insights from distance science educators regarding their conceptualizations and implementations of CRST approaches to their science teaching practices (Appendix D for interview questions posed). The process continued with an analysis of the information received from distance science educators using a grounded theory approach with an inductive coding process, and finally, juxtapositioning the findings with existing literature on CRST. The new understanding of CRST in the context of distance science education consists of three main components: (1) Challenges, (2) Affordances, and (3) Applications. The framework begins with challenges as the teacher participants were faced with the challenges of applying CRST online before they recognized and utilized the tools (deemed affordances) required for CRST application in the online setting.

Distance science educators' challenges with implementing CRST included: (i) lack of physicality and (ii) curriculum and pedagogical constraints. The lack of physicality posed unique challenges for distance science educators with: (a) building a safe space for students to communicate online for authentic self-expression, and (b) implementing culturally responsive experiential learning opportunities by distance. The curriculum and pedagogical constraints included: (a) volume of curriculum content with time as a limitation, (b) lack of reference to CRST in the science curriculum guides, (c) lack of resources on CRST for distance science educators (d) lack of material on Indigenous scientific knowledge within the curriculum guides and (e) lack of professional learning opportunities for distance science educators on CRST.

Despite the significant challenges with implementing CRST in the online setting, distance science educators were adept at applying CRST to their teaching practices due to reasons termed affordances in this study.

The affordances of CRST included: (i) creating a safe space for student voice in the educational online setting and (ii) creating a safe space for students by respecting their cultures and rural identities. Creating a safe space online for student-teacher communication required: (a) utilizing communications technologies in a safe and inclusive way and (b) employing formal and informal communication styles. Respecting student cultures and rural identities involved: (a) recognizing and celebrating the differences among students, (b) ensuring that the students' cultures and rural identities are represented in science, and (c) honoring students' local dialects. Due to these affordances, distance science educators were able to apply CRST in their teaching practices—termed applications in this study.

The applications of CRST involved the use of: (i) Culturally Relevant Project-Based Learning (CRPBL) and (ii) Culturally Relevant Subject Matter (CRSM). The application of CRPBL involved: (a) community ties to scientific problems, (b) the inclusion of local and Indigenous scientific knowledge in science projects, and (c) the integration of relevant socio-scientific issues with scientific outcomes in the form of scientific investigations. CRSM included: (a) culturally relevant questions and examples in teaching practices, (b) local and Indigenous scientific knowledge in course content, and (c) relevant socio-scientific issues in teaching scientific outcomes.

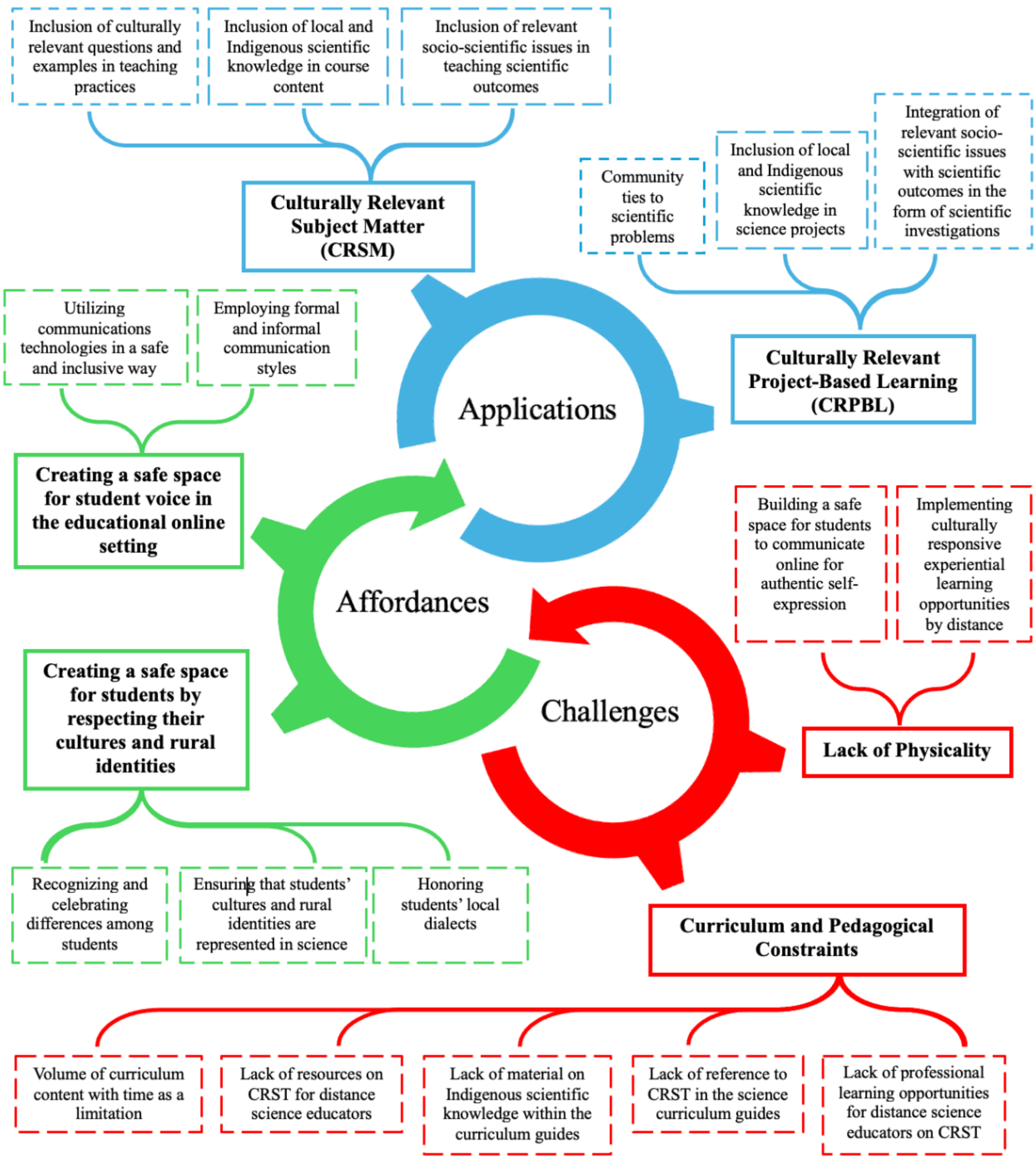

Figure 1. CRST Framework for Distance Science Education

5.5 Implications

This section will highlight the implications of CRST in the context of NL's public school system (NL Schools) with attention to its' science education program and its' distance education component (CDLI), as well as the implications for future research possibilities.

5.5.1 Implications for Science Education

The "Context for Teaching and Learning" in the NL science curriculum guides emphasize several factors that make up the educational context in NL: Inclusive Education, Literacy, Learning Skills for Generation Next, and Education for Sustainable Education (Science 1206, Curriculum Guide, 2018). The foundation of the curriculum outcomes framework for all NL science courses are considered general curriculum outcomes (GCOs) and include four aspects of students' scientific literacy: (i) science, technology, society, and the environment (STSE), (ii) skills, (iii) knowledge, and (iv) attitudes (Science 1206, Curriculum Guide, 2018). This section will highlight the implications of CRST, specifically, within "The Context for Teaching and Learning", as well as the four GCOs of student scientific literacy. The section will then elaborate on the implications for science curricula and pre-service teacher education in general.

The NL science curriculum guides affirm that "all students need to see their lives and experiences reflected in their school community" (Science 1206, Curriculum Guide, 2018, p. 4) in their definition of inclusive education. This statement on inclusive education is the foundation of CRST. The curriculum guides proceed to describe an inclusive classroom as one that "values the varied experiences and abilities as well as social and ethnocultural backgrounds of all students while creating opportunities for community building" (Science 1206, Curriculum Guide, 2018, p. 4). CRST aligns with the description of inclusive policies and practices as both “promote mutual respect, positive interdependencies, and diverse perspectives. Learning resources should include a range of materials that allow students to consider many viewpoints and to celebrate the diverse aspects of the school community” (Science 1206, Curriculum Guide, 2018, p. 4).

The foundation of the curriculum outcomes framework for all NL science courses are considered general curriculum outcomes (GCOs) and include four aspects of students’ scientific literacy: (i) science, technology, society, and the environment (STSE), (ii) skills, (iii) knowledge, and (iv) attitudes (Science 1206, Curriculum Guide, 2018). The first GCO from the NL Science 1206 curriculum guide (2018) titled, “Science, Technology, Society, and the Environment (STSE)” is declared to develop “[students’] understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology” (p. 20). The social and environmental contexts of science and technology can be closely aligned with CRST if lessons reflect students’ cultures and rural identities. The second GCO titled “Skills”, pertains to the development of “[students’] skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions” (p. 20). CRPBL can be attained through the second GCO as students collaborate with their communities to investigate relevant socio-scientific issues through inquiry. Within the third GCO “Knowledge”, students will “construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge” (p. 20). An extension of this GCO should include Indigenous Scientific Knowledge (ISK), where the “construction” of knowledge can appear different in the various Ways of Knowing, such as Coming to Know. The fourth and final GCO is titled "Attitudes" as students "are encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment" (p. 20) Self, society, and the environment are integral parts of rural cultures and lifestyles; therefore CRST is vital in supporting scientific knowledge—including local and Indigenous scientific knowledge—and careful attention paid to the technologies that may benefit or harm the cultures within it (Science 1206, Curriculum Guide, 2018).

CRST may also be adopted to the Responsive Teaching and Learning (RTL) Policy from the Department of Education (2023) as they define RTL as "an approach to education that emphasizes social-emotional and academic learning in a safe, healthy and inclusive school environment." (p. 10). The approach emphasizes reflection and adaptation in teaching practices to support student learning.

Implications for CRST in distance science education is not limited to the NL science curriculum; CRST may be adopted to curriculum outcomes of other provinces and science curriculums provided in other regions across the country and the world. CRST may be implemented within existing curriculum outcomes (implicitly) or explicitly adopted to new curriculums through curriculum development. CRST for distance education can be included in pre-service teacher education programs and taught in conjunction with Indigenous education.

5.5.2 Suggestions for Future Research

Suggestions for future research may include the study of:

(a) secondary science students' experiences with CRST-infused science lessons in the context of distance education within the province of NL,

(b) the experiences of distance educators with CRST from other provinces,

(c) experiences of distance educators with CRST by including multiple data sources such as non-participatory observations, examination of distance educators' artifacts, students' experiences through surveys and/or interviews,

(d) experiences of rural and urban educators related to their applications of CRST, and

(e) to affirm the proposed CRST framework in this research in other contexts.

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Appendices

Appendix A: Ethics Approval Form and Extended Clearance Approval

MEMORIAL UNIVERSITY

Interdisciplinary Committee on Ethics in Human Research (ICEHR)

St. John's, NL Canada A1C 5S7
Tel: 709 864-2561 icehr@mun.ca
www.mun.ca/research/ethics/humans/icehr

ICEHR Number:	**20240012-ED**
Approval Period:	May 4, 2023 – May 31, 2024
Funding Source:	
Responsible Faculty:	Dr. Saiqa Azam Faculty of Education
Title of Project:	*Science Teachers' Culturally Responsive Practices in the Context of Distance Education: A Mixed Methods Study*

May 4, 2023

Mrs. Michelle Hamilton
Faculty of Education
Memorial University of Newfoundland

Dear Mrs. Hamilton:

Thank you for your correspondence addressing the issues raised by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) for the above-named research project. ICEHR has re-examined the proposal with the clarifications and revisions submitted, and is satisfied that the concerns raised by the Committee have been adequately addressed. In accordance with the *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS2)*, the project has been granted *full ethics clearance* for **one year**. ICEHR approval applies to the ethical acceptability of the research, as per Article 6.3 of the *TCPS2*. Researchers are responsible for adherence to any other relevant University policies and/or funded or non-funded agreements that may be associated with the project. If funding is obtained subsequent to ethics approval, you must submit a Funding and/or Partner Change Request to ICEHR so that this ethics clearance can be linked to your award.

The *TCPS2* **requires** that you **strictly adhere to the protocol and documents as last reviewed** by ICEHR. If you need to make additions and/or modifications, you must submit an Amendment Request with a description of these changes, for the Committee's review of potential ethical concerns, before they may be implemented. Submit a Personnel Change Form to add or remove project team members and/or research staff. Also, to inform ICEHR of any unanticipated occurrences, an Adverse Event Report must be submitted with an indication of how the unexpected event may affect the continuation of the project.

The *TCPS2* **requires** that you submit an Annual Update to ICEHR before **May 31, 2024**. If you plan to continue the project, you need to request renewal of your ethics clearance and include a brief summary on the progress of your research. When the project no longer involves contact with human participants, is completed and/or terminated, you are required to provide an annual update with a brief final summary and your file will be closed. All post-approval ICEHR event forms noted above must be submitted by selecting the ***Applications: Post-Review*** link on your Researcher Portal homepage. We wish you success with your research.

Yours sincerely,

James R Drover

James Drover, Ph.D.
Vice-Chair, Interdisciplinary Committee on
Ethics in Human Research

JD/bc

cc: Supervisor – Dr. Saiqa Azam, Faculty of Education

Maan, Michelle <mdh851@mun.ca>

ICEHR Clearance # 20240012-ED – EXTENDED

dgulliver@mun.ca <dgulliver@mun.ca> Mon, May 6, 2024 at 11:05 AM
To: "Hamilton Michelle(Principal Investigator)" <mdh851@mun.ca>
Cc: "Azam Saiqa(Supervisor)" <sazam@mun.ca>, dgulliver@mun.ca

Interdisciplinary Committee on
Ethics in Human Research (ICEHR)

ICEHR Approval #:	20240012-ED
Researcher Portal File #:	20240012
Project Title:	*Science Teachers' Culturally Responsive Practices in the Context of Distance Education: A Mixed Methods Study*
Associated Funding:	Not Funded
Supervisor:	Dr. Saiqa Azam
Clearance expiry date:	**May 31, 2025**

Dear Mrs. Michelle Hamilton:

Thank you for your response to our request for an annual update advising that your project will continue without any changes that would affect ethical relations with human participants.

On behalf of the Chair of ICEHR, I wish to advise that the ethics clearance for this project has been extended to **May 31, 2025**. The *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans* (TCPS2) requires that you submit another annual update to ICEHR on your project prior to this date.

We wish you well with the continuation of your research.

Sincerely,

DEBBY GULLIVER
Interdisciplinary Committee on Ethics in Human Research (ICEHR)
Memorial University of Newfoundland
St. John's, NL | A1C 5S7
Bruneau Centre for Research and Innovation | Room IIC 2010C
T: (709) 864-2561 |
www.mun.ca/research/ethics/humans/icehr | **https://rpresources.mun.ca/**

Appendix B: Participant Recruitment Script to CDLI Director for the Recruitment of CDLI Science Teachers in Research Study

Recruitment Script (CDLI Director)

Email Subject Line: Request to Recruit CDLI Science Teachers in Research Study

Dear [Director],

I, Michelle Hamilton, am a second-year graduate student of the Curriculum, Teaching, and Learning master's thesis program in the Faculty of Education at Memorial University of Newfoundland, and my supervisor, Dr. Saiqa Azam, is an Associate Professor of Science Education in the Faculty of Education.

I am contacting you to request the recruitment of CDLI science teachers to participate in my research study on Culturally Responsive Science Teaching (CRST) practices in NL distance science education. I kindly ask if may forward this email with the Recruitment Letter attached to all CDLI science teachers.

Please see the Recruitment Letter attachment for details of what the study entails, its purpose, and significance.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research, such as the way you have been treated or your rights as a participant, you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

Appendix C: Informed Consent Form

Informed Consent Form – Teacher Interview

Principal Investigator
Michelle Hamilton, B.Ed.

Graduate Student
Faculty of Education
Memorial University of Newfoundland
St John's NL, Canada, A1B 3X8

Email: mdh851@mun.ca

Phone (Cell): (709) 687-1656

Master's Thesis Supervisor
Saiqa Azam, PhD

Associate Professor
Faculty of Education
Memorial University of Newfoundland
St John's NL, Canada, A1B 3X8

Email: sazam@mun.ca

Phone (Office): (709) 864-3413

You are invited to take part in a research project entitled: *Science Teachers' Culturally Responsive Practices in the Context of Distance Education: A mixed Methods Study*

This form is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study. To decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is the informed consent process. Take time to read this carefully and understand the information given to you. Please contact the Researcher (Michelle Hamilton) or Research Supervisor (Saiqa Azam) if you have any questions about the study or would like more information before you consent.

Introduction

I, Michelle Hamilton, am a second-year graduate student in the Curriculum, Teaching, and Learning master's thesis program in the Faculty of Education at Memorial University of Newfoundland. Dr. Saiqa Azam is an associate professor of science education in the Faculty of Education, at Memorial University of Newfoundland.

We are currently engaged in a research project on the development of rural, distance science education entitled, *Science Teachers' Culturally Responsive Practices in the Context of Distance Education: A mixed Methods Study*. The research project involves investigating Culturally Responsive Science Teaching (CRST) practices in the Newfoundland and Labrador (NL) distance science education program through the Center for Distance Learning and Innovation (CDLI). Culturally Responsive Teaching (CRT) involves three pillars in teaching: (i) academic success, (ii) cultural competence, and (iii) critical consciousness. With a focus on science, CRST can safeguard access to science with the inclusion of diverse ways of knowing (bridging Western ways of knowing with rurality, and cultural identity). NL culture is rooted in ways of knowing science through Indigenous, Irish, and French heritage, and subsequent traditional community customs with deep ties to the ocean and the land. The practice of CRT is particularly challenging for distance educators where a standardized science curriculum is in place through the NLESD, and diverse, remote communities merge for synchronous online learning—this is the case in rural NL where communities are small, sparse, and isolated.

Appendix D: Interview Questions

Teacher Interview Questions

Section 1: Demographic

A. How many years have you been teaching science in high school?
B. How many years have you been teaching science by distance?
C. What science disciplines do you have experience teaching (by distance)?

Section 2: Knowledge and Source(s) of Knowledge of CRST

A. What is your familiarity with culturally relevant science teaching (CRST)? Other terminology may include Culturally Relevant Teaching, and Culturally Relevant and Responsive Pedagogy (CRRP).
B. Have you received any professional learning opportunities about CRT? If so, can you describe your experience? [Prompt: Was this experience science-focused? Did you learn anything that can be adopted in the science classroom?]

Section 3: Practice & Pedagogy

A. In what way(s) do you come to understand the ideas and experiences of your students regarding their culture and rurality?
B. In what way(s) do you make your lesson/teaching culturally relevant for your CDLI science students?
C. Explain how you may use the lived experiences of students, including your students' families, communities, and cultures, as valued parts of the instructional plan and discourse in your online science classroom. [Prompt: Can you provide an example?]

Section 4: Inclusion of students/parents/community

A. In what way(s) do you allow for a safe space through CDLI for students to discuss their cultures, and their communities? [Prompt: Can you provide an example?]
B. Have you ever allowed your students to discuss the socio-cultural issues important in their communities? [Prompt: If yes, can you describe this experience?]
C. Have you ever provided opportunity for CDLI science students to become involved in community advocacy through science as part of your lesson plan? [Prompt: If yes, can you provide an example?]
D. Have you ever included parents/guardians in the decision-making process regarding course content and delivery? [Prompt: If yes, can you describe this experience? What impact did their decisions have?]

Appendix E: Pan-Canadian Protocol for Collaboration on School Curriculum by the Council of Ministers of Education of Canada

cmec

Council of Ministers of Education, Canada

PAN-CANADIAN PROTOCOL
FOR COLLABORATION ON SCHOOL CURRICULUM

WHEREAS education in Canada is a provincial responsibility;

WHEREAS the ministers of education are committed to the improvement of the quality of education provided in their provinces and territories and believe that inter-jurisdictional cooperation can contribute to the realization of that objective;

WHEREAS the ministers recognize that we share many common educational goals and agree to ensure greater harmonization of the ways we set about achieving them;

WHEREAS the ministers of education wish to enter into an agreement to facilitate curriculum collaboration among the provinces and territories, recognizing that shared resources, both human and financial, can increase the quality and efficiency of the curriculum development process;

WHEREAS the ministers wish all citizens to have a fair and equitable opportunity in education and wish to provide increased accessibility to education; and

WHEREAS the ministers recognize and respect the distinct character of francophone and anglophone education;

THEREFORE, the parties agree as follows:

PART 1 - Object of Collaboration

The following matters relating to education for learners from entry to end of secondary schooling (grade 12) may be the object of collaboration among interested parties:

1.1. identification of curriculum outcomes and related standards;

1.2. curriculum in the English language;

1.3. curriculum in the French language;

1.4. assessment of student performance;

1.5. application of technology to curriculum and the use of distance education for delivery;

1.6. the establishment of means for exchanging information electronically and in other ways among the parties.