ANTI-OPPRESSIVE SCIENCE TEACHING: AN INVESTIGATION OF INTERMEDIATE AND SECONDARY SCIENCE TEACHERS' VIEWS AND PRACTICES

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Abstract

Whether via outright abuse, exploitation, neglect, or exclusion, the oppression of marginalized identities within science is a long-standing and well-documented phenomenon. In the absence of intentional and concerted efforts, school science programs can perpetuate this oppression. Anti-oppressive pedagogy is a set of theories and practices which seeks to challenge this, to dismantle oppressions within and beyond the classroom, and to liberate students. The purpose of this research study was to examine teachers' views on and use of anti-oppressive teaching in intermediate-secondary science classrooms in Newfoundland and Labrador. The study employed a mixed methods design, which incorporated a digital questionnaire and semi-structured interviews with science teachers. The results demonstrated significant variability among local teachers' perspectives. Several participants expressed a lack of awareness in relation to oppression in science, and some expressed resistance to engaging with such topics in their classes. There was also considerable disparity observed in terms of teachers' reported implementation of anti-oppressive teaching practices. Overall, findings indicated that the integration of these practices within local intermediate and secondary science programs is severely limited. The study revealed several factors which influence teachers' engagement with anti-oppressive teaching. Consideration of these factors, together with existing literature, illuminated some key actions for advancing anti-oppressive science teaching and promoting equity in science.

Keywords: *Science Education, Anti-Oppressive Education, Transformative Education, Teacher Practice*

General Summary

This study aimed to examine teachers' views on and use of anti-oppressive teaching in intermediate-secondary science classrooms in Newfoundland and Labrador. While the literature on anti-oppressive teaching is growing, there is limited research specific to science teaching, most existing literature focuses on theory rather than practice, and there is a gap in the research in the local context. This study employed a digital questionnaire as well as semi-structured interviews with local intermediate and secondary science teachers. The findings indicate considerable variability in terms of teachers' perspectives as well as their practices. Overall, findings demonstrate that the integration of anti-oppressive teaching within local science classes is limited. Teachers cite their own personal experiences, time and curriculum constraints, and training deficits as relevant factors. These factors and existing literature highlight a need for additional research and collaboration between stakeholders to ultimately develop a framework to promote anti-oppressive teaching and equity in science through curriculum changes, enhanced professional development and more.

Acknowledgments

I'm compelled to use this space in a manner that it is not typical because the circumstances in which I write this are not typical. The completion of this thesis was delayed by my involvement in, and arrest for, peaceful protest againts Memorial University of Newfoundland and Labrador's complicity in the ongoing genocide in Palestine. Rather than use this space to acknowledge those that have supported this thesis work I instead acknowledge the work that is needed.

I acknowledge the horrific, ongoing genocide in Palestine and the inhumanity and the pervasive silence that enables it. I acknowledge the hypocrisy of MUN and all the colonial institutions that repeat land acknowledgments, offer courses on social justice, and host conferences on equity at the same time that they choose to send armed police to arrest protesters opposing their institutions funding of weapons, war crimes, and crimes against humanity. I acknowledge that we all have power and we all have responsibility. I acknowledge all those who are silent because they don't have enough to lose but have told themselves they have too much to lose.

It is August 2024 and the current genocide has been ongoing for 10 months. The ICJ has ruled the occupation illegal. The UN has named Israel's crimes against humanity and war crimes including extermination and starvation as a method of warfare and has clearly warned states and companies facilitating the supply of weapons to Israel that they risk complicity. Still MUN administration including Neil Bose and Jennifer Lokash and the Board of Regents including Chair Glenn Barnes affirm their commitment to remain materially invested in these entities, all the while claiming their "neutrality".

I acknowledge and commit to all the work that is left to do. Free Palestine.

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Chapter 1: Introduction

Oppression is defined by Taylor as a form of injustice that occurs when one social group is subordinated while another is privileged (2016). Oppression is a complex social dynamic that is maintained by a variety of mechanisms, including social norms, stereotypes, and institutional rules (Cudd, 2006; Taylor, 2016). Within the field of science, the oppression of certain marginalized groups is a long-standing and well-documented issue. Racialized people, Indigenous people, Queer people, women, and people with disabilities have historically been and continue to be oppressed in science spaces through outright abuse, exploitation, neglect, and/or exclusion. While some efforts to address this have been made, the inequity persists today. Members of these marginalized groups continue to be underrepresented in science programs and workplaces (Charlesworth & Banaji, 2019; Institute of Physics, Royal Astronomical Society & Royal Society of Chemistry, 2019; Lindsay et al., 2019; Napper et al, 2002) and face increased instances of discrimination and harassment within these spaces (Cech & Waidzunas, 2021; Nash, 2021).

Conversations around oppression, including in the context of education, have been ongoing for several decades (Freire, 2005). They have, however, come to the forefront in recent years precipitated by significant events such as the Truth and Reconciliation Commission of Canada's inquiry into Indigenous residential schools, the Black Lives Matter Movement, and the rise of anti-trans sentiments and legislation, among other factors (Paterson, 2023). The literature suggests the importance of schools in addressing oppression and stresses the role of classroom teaching practices in particular

(Bottia et al., 2021; Dedotsi & Paraskevopoulou-Kollia, 2019). A host of movements focused on equity in education have arisen under various names (Kelly, 2012). Social justice teaching, culturally responsive teaching, equity-focused education, transformative education, anti-racist education, inclusive education, and multicultural education are just a few examples. The differences among these movements range from subtle to more significant, both in terms of their objectives and approaches. Culturally responsive and multicultural education for example tend to focus on supporting ethnic and cultural diversity while the term inclusive education is most often employeed in discussions of supports and services for students with disabilities. While elements of each of these movements can be found within the umbrella of anti-oppressive teaching, some of the aforementioned movements tend to lack the focus on critical consciousness, which is central to anti-oppressive teaching. Several sources criticize the tendency for diversity and inclusion movements to be overly simplistic or celebratory (Kelly, 2012; Le & Matias, 2019; St Clair & Kishimoto, 2010). St Clair & Kishimoto (2010) explain that many of these movements "fail to provide an analysis of the political, institutional, and ideological structures that underpin discrimination and social disparities" and, as such, attempt to celebrate diversity while "dodging the challenging issues." This is the type of half-work we engage in when we observe Orange Shirt Day in schools named after John A. Macdonald and neglect to name the duplicity or when we give young girls Scientist Barbies and say they can be anything but avoid confronting the obstacles of gender-based bias and harassment that exclude or force girls out of those arenas. In reference to Indigenous oppression and the Truth and Reconciliation process in Canada there has

emerged a maxim “there can be no reconciliation without truth” (Truth and Reconciliation Commission of Canada, 2015). To borrow this sentiment, there can be no equitable science education without recognition of the pervasive historical and ongoing role of oppression in science. For this reason, this study favours a focus on anti-oppressive teaching while also incorporating other equity movements in education where appropriate.

There is a great deal of research concerned with oppression in science, and a considerable amount which focuses on the experiences of marginalized students in science. The literature on anti-oppressive teaching is growing, though there is a limited focus on anti-oppressive teaching in a science-specific context. There is a gap in the literature as far as analyzing the extent to which science teachers are practising anti-oppressive teaching or the strategies they are using. There is no available research that examines anti-oppressive teaching practices in the context of Newfoundland and Labrador science classrooms. This study aims to begin the work of filling this research gap.

1.1 Study Context

As mentioned, recent events have seen conversations around oppression and anti-oppressive work take a more prominent role in public dialogue. The Newfoundland and Labrador Department of Education has engaged in these conversations through official statements and through the promotion of generic equity and inclusion resources. However, there does not appear to be a concerted effort to incorporate outcomes focused

on oppression throughout relevant curriculum domains at the intermediate and secondary levels or to engage teachers in developing anti-oppressive teaching strategies. Based on the researchers review, none of the seven high school science curricula released over the past four years have included any meaningful outcomes related to oppression in science. Efforts to promote awareness and competency around anti-oppressive practices among teachers have also been limited. While some optional professional development opportunities around topics related to anti-oppressive teaching have been offered in recent years, most participants of this study indicated they were not aware of them. There has been no mandated professional development for intermediate-secondary teachers related to oppression or anti-oppressive teaching in at least the past decade and there have been no opportunities for science-specific professional development in this area. The Department of Education's policies and statements are promising. However, it is unclear how these intentions can, in the absence of comprehensive curriculum integration or professional development, trickle down to facilitate anti-oppressive teaching at the classroom level.

1.2 Purpose Statement

The purpose of this study is to critically analyze and describe teachers' views on and use of anti-oppressive teaching practices in intermediate-secondary science classrooms in Newfoundland and Labrador. The study examines current teaching practices as well as those factors which might influence teacher practices, such as

personal background and knowledge, time constraints, access to resources, and perception of administrator or district support.

The immediate goal of the study is to develop an understanding of anti-oppressive practices in science classrooms throughout Newfoundland and Labrador. The objective of this research study is to investigate intermediate and secondary science teachers' views and practices regarding anti-oppressive science teaching. The following three research questions guided this study; (1) What are science teachers' views of oppression and anti-oppressive teaching in science? (2) To what extent and in what ways are teachers employing anti-oppressive science teaching? (3) What factors promote or limit teachers' implementation of anti-oppressive science teaching?

The longer-term ambition is that this information is used to support future research and collaboration, which might promote the planning and provision of professional development and other supports that could improve the implementation of anti-oppressive science teaching in Newfoundland and Labrador.

This qualitative research study employed a mixed methods design. Because each data collection method has unique strengths and limitations, the use of multiple collection methods can help improve saturation and ensure validity. Data in this study was collected using the questionnaire found in Appendix D followed by semi-structured synchronous interviews based on the script in Appendix E. Data was coded and analyzed using MAXQDA to allow common themes to emerge. Triangulation between participants and between data collection instruments was incorporated in addition to member checks to ensure the validity of results.

1.3 Positioning the Researcher

It should be disclosed that the researcher is an intermediate-secondary science teacher with some personal overlap with the communities for which oppression in science is a concern. The researcher is also currently employed by the same school district where the study was conducted. These lived experiences and personal circumstances can be considered an asset to the study. Whitt states that "effective qualitative inquiry requires that the researcher be familiar not only with qualitative research methods but also with the phenomena under study" (p. 408,1991). Eisner also emphasizes the role of the researcher as an instrument of research and suggests that the researcher "acknowledge and exploit their own subjectivity" and "personal insight" (Eisner, 1998).

It is also important to acknowledge that these same personal experiences that the researcher may leverage to inform their research can pose a potential source of bias. Several steps were taken to mitigate this and to protect the validity of the study. Tite (2010) suggests that the two principal methods for establishing the trustworthiness of qualitative research are triangulation and precise description. Stahl and King (2020) also promote the use of triangulation as a method to establish trustworthiness in the context of education research. They describe triangulation as as "the use of multiplicity to test the credibility of one's research" (Stahl & King, 2020). Tite explains that triangulation can be achieved through the following means: Engaging in more than one type of data collection, involving multiple "researchers" or individuals in the data collection process, and member checking (2010). Creswell also states that triangulation can include corroboration between different individuals, types of data, or data collection methods

(2012, p. 259). This study follows each of these recommendations from Tite and Creswell as numerous individuals were surveyed and interviewed and member checking was employed as participants had the opportunity to review their own interview transcripts. There are also distinct types of data and collection methods which allow for triangulation.

Chapter 2: Literature Review

This chapter begins by clarifying the definition of oppression employed in the study. A rationale is provided for the study's broad approach to oppression as opposed to a focus on any one marginalized population. The chapter goes on to contextualize oppression as it relates to science, outlining how science and science education have historically oppressed certain populations. It also acknowledges the numerous ways in which marginalization continues within these spaces. An argument is made for the role of teaching practices as one important component of anti-oppressive education. This is followed by an examination of the existing literature as it relates to anti-oppressive teaching practices in science. This examination includes theoretical works, research studies, and teacher guides. The chapter concludes with a brief exploration of the potential limiting factors that dissuade teachers from engaging in anti-oppressive teaching in science.

2.1 Oppression

There is no one universally accepted definition of the term "oppression." It can be understood in various ways, and the use of the term has evolved over time.

Merriam-Webster's Dictionary defines oppression as "unjust or cruel exercise of authority or power" (n.d). It originates from the Latin "oppressiō" meaning "action of pressing on or overpowering" (Merriam-Webster, n.d). Paulo Freire was one of the first to examine oppression in the context of education. He defines oppression as "any situation in which "A" objectively exploits "B" or hinders his and her pursuit of self-affirmation as a responsible person" (2005, p. 55). This definition is a suitable starting point, though incomplete, as it may falsely suggest that oppression operates solely on the level of the individual. Furthermore, Freire's definition focuses on exploitation only, which is just one presentation of oppression. The Chinook Fund (2015) explains that there are several, interconnected forms of oppression. They describe these forms as the 4 I's; Ideological- the core idea or belief that one group is inherently superior to another, Institutional- discrimination that is embedded in institutions and creates systemic inequalities that favor the dominant group, Interpersonal- Individual actions of prejudice or mistreatment that reflect and reinforce broader societal power imbalances, and Internalized- When individuals from oppressed groups begin to accept and believe the negative stereotypes and ideologies imposed on them (Chinook Fund, 2015). Kumashiro's definition accounts for multiple aspects of oppression stating that it is a social dynamic in which certain ways of identifying or being identified are normalized or privileged while other ways are disadvantaged or marginalized (2002). Similarly, focusing on the social aspect, Taylor (2016) stated:

> Oppression is a form of injustice that occurs when one social group is subordinated while another is privileged…oppression is maintained by a variety

> of different mechanisms, including social norms, stereotypes, and institutional rules (p. 520).

Taylor's definition is adopted in this research study. This definition is preferred because it is both comprehensive and concise. It centers on social groups, accounts for privileging as well as marginalization, and acknowledges the diversity of mechanisms that produce and maintain oppression. Taylor's definition is also preferred in the context of this study because it acknowledges that oppression need not be intentional. Though there are many cases in which oppression is intentional, intention is not a necessary feature of oppression. Both Freire and Taylor clarify this and stress that oppression is a complex phenomenon that is upheld through a network of mechanisms embedded in society and often maintained through unconscious, ingrained attitudes and beliefs (Freire, 2005; Taylor, 2016). According to Taylor (2016) the term did historically focus on deliberate subjugation, however, throughout the nineteenth and twentieth centuries it experienced a shift to acknowledge "more subtle, complex, and systemic instances of injustice" (p. 521). In *Analysing Oppression*, Cudd (2006) outlined a similar shift in meaning and also noted the importance of factors that are not necessarily intentional including traditions, prejudice, and social expectations (p. 9). A definition of oppression that accounts for unintentional and unconscious forms of oppression is required here because this study focuses on classroom science teaching. Though some of the oppression that occurs within science is certainly intentional (this will be expanded on below) it is expected that the oppression reinforced within science classrooms is typically unintentional, unconscious, and often perpetuated through inaction as much as action (Kumashiro, 2012).

Taylor's (2016) definition of oppression centres on the role of social groups. Some groups which experience oppression in science include racialized people, Indigenous people, Queer people, women, and people with disabilities. Individuals who belong to these and other marginalized groups, as well as those who exist at the intersections, have been oppressed and disadvantaged within fields of science and science education in various ways (Block et al., 2019; Broyles & Fenner, 2010; Charlesworth & Banaji, 2019; Halpin, 1989; Institute of Physics et al., 2019; Landivar, 2013; Rainey et al., 2018). Specific examples are outlined in later sections within this chapter. Morales-Doyle (2017) explains how racism, colonialism, sexism, and economic exploitation are each hegemonic in their own right and are all interrelated. Thus, it is important to examine them through an intersectional lens. Kumashiro (2000) supports this in the context of science education, stating, "the multiple and intersecting identities of students make difficult any anti-oppressive effort that revolves around only one identity and only one form of oppression (p. 38)". For this reason this study considers oppression in a broad sense and does not focus on any one specific marginalized group. It is important to note that this is not meant to imply that these groups or the oppression they face are the same. It is, however, an acknowledgment of the fact that all systems of oppression are intimately connected.

2.1.1 Oppression in Science

As previously noted, oppression can take many forms. It may be overt or covert and is often complex and multifaceted. As such, a full examination of oppression in

science is not possible within the scope of this research; however, some brief examples are shared in the following section. These are meant only to demonstrate the diverse ways in which oppression may manifest itself within science and science education. This does not represent an exhaustive list of issues impacting marginalized identities in science. It should also be noted that this section refers to modern, Western (white) science, which most school science is centred on. The dominance of this form of science will be problematized later.

In the most overt form, the study of science has itself been employed as an instrument in the development and maintenance of oppressive structures. Carl Linnaeus, "the father of modern taxonomy," was one of the first to classify humans into distinct "varieties," which laid the foundation for the modern concept of race and for scientific racism (Charmantier, 2020). Scientific research and data have been used throughout history in attempts to falsely establish the superiority of certain identities over others (Belkhir, 1994; Clough & Orozco, 2016). This continues throughout modern times as Paulo Freire claims, "more and more, the oppressors are using science and technology as unquestionably powerful instruments for their purpose: the maintenance of the oppressive order through manipulation and repression" (2005, p. 60). Oppressed groups have particularly been victimized within medical research. James Marion Sims performed experimental surgeries on enslaved Black women without their consent (Spettel & White, 2011), the Tuskegee Syphilis Study saw hundreds of Black men deceived about their illness and treatment for nearly 40 years (Reverby, 2012), and many studies in medicine and psychology pathologized gender and sexuality differences (Martin, 1993). It is also

important to note that long after any explicit effort to exploit science as a tool of oppression has ceased, the repercussions persist. Such is the case, for example, when long-debunked theories of biological differences between races continue to affect disparities in pain treatment for racialized patients (Hoffman, 2016).

Oppression can also take on a more covert form and there are many instances where science has oppressed marginalized groups through neglect rather than outright abuse (500 Women Scientists Leadership, 2020). For example, proponents of advancing technologies such as facial recognition often ignore the frequent racial bias and the potential implications of that bias for racialized people which can include issues from ineffective functions to excessive surveillance and false arrest (Perkowitz, 2021; Skinner, 2020). Similarly, environmental science often overlooks how environmental issues from pollution to climate change disproportionately impact racialized people (Funes, 2018; Lakhani, 2019). In the early days of the AIDS epidemic, while it was believed to only threaten homosexual men, few resources were mobilized to respond to the tragedy (Mohr, 2010; Terry, 1999). Fields of biology and medicine, including high school biology curriculum, often conflate the terms "gender" and "sex." They also tend to omit discussions of intersex identities or else represent them as disorders rather than as a natural element of human diversity (Newfoundland and Labrador Department of Education, 2004). By failing to confront its inherent bias or the repercussions of that bias, the study of and advancements of science have served to benefit certain groups while neglecting or even harming others. In this way, science works to reinforce patterns of oppression.

One of the primary reasons that science has failed to serve marginalized demographics is that these individuals are often minoritized in places of science. Racialized people, indigenous people, women, queer people, and people with disabilities are generally underrepresented in post-secondary science programs and science workplaces compared to the general population (Charlesworth & Banaji, 2019; Institute of Physics, Royal Astronomical Society & Royal Society of Chemistry, 2019; Lindsay et al., 2019). In discussing the underrepresentation of people with disabilities in STEM (Science, technology, engineering, and math), Napper et al. (2002) note an absence of role models as an important factor. Lewis et al. (2016) echo this same point in their study of women's experiences in Physics. Young people are not afforded these role models in part because, for much of history, scientific arenas have actively barred access to marginalized communities. Where members of these communities did have access and opportunities to make advancements in science, their contributions were largely ignored or misattributed (Okun & Kwan, 2016). Such is the case when the names of women like Cecilia Helena Payne-Gaposchkin and Rosalind Franklin are forgotten in favour of the men who were credited for their work (Rossiter, 1993). Opportunities to uphold role models for people with disabilities in science are also missed when an individual's accomplishments are promoted while erasing their disability. Not acknowledging Newton’s struggles with mental illness or Annie Jump Cannon’s hearing loss is a failure to allow students with similar challenges the opportunity to see themselves in the subjects they are studying (Rousso, 2008; Wakely & Carson, 2011). The underrepresentation and underrecognition of marginalised identities in science contributes to a gap in role models

which in turn undermines efforts to inspire marginalized youth to pursue science. In this way, the issue of underrepresentation is perpetuated in a cycle.

For marginalized people who do choose to pursue science fields, there are many barriers to entrance and success. Several studies have demonstrated discrimination in admittance for academic science programs as well as discrimination and harassment of various forms within these programs and within the science workforce (Cech & Pham, 2017; Eaton et al., 2020; Johnson et al., 2018; Macdonald, 2020; McCoy et al., 2015). This mistreatment, coupled with wider racial, ethnic and gender pay gaps in STEM compared to other fields, contributes to higher levels of attrition (Fry et al., 2021). Furthermore, Johnson et al. (2018) found that individuals from non-majority groups cannot bring their "whole selves" to their work and often adopt conformity behaviours. They describe how this adaptation is distracting and limiting when trying to do complex work and explain that it inhibits scientists from leveraging their diverse experiences into novel problem-solving capabilities.

2.1.2 Consequences of Oppression in Science

The factors cited above have led to what Funes (2018) describes as a "diversity crisis" in science. The absence of diversity leads to increased oppression, which then further limits diversity, perpetuating a cycle of exclusion. Because science and innovation thrive on diversity, therefore, lack of diversity " is not only morally wrong and profoundly unfair; it's also devastating to science itself" (500 Women Scientists Leadership, 2020). Funes (2018) discussed several examples of instances in health and

environmental science where a lack of diversity permitted gaps in understanding. Graves et al. (2022) further contend that the exclusionary legacy of oppression in science has resulted in a system of research and innovation that is suboptimal and demographically restricted. They claim the lack of diversity contributes to narrow focus in research priorities and a hindered ability to effectively transfer knowledge from science to society. Graves et al. argue for a new agenda to promote diversity in science. Figure 1 below, from Graves et al. (2022), effectively summarises the benefits of equity and representation in science . The circular structure and use of arrows within this diagram highlight how improvements in each sector further promote progress in other capacities.

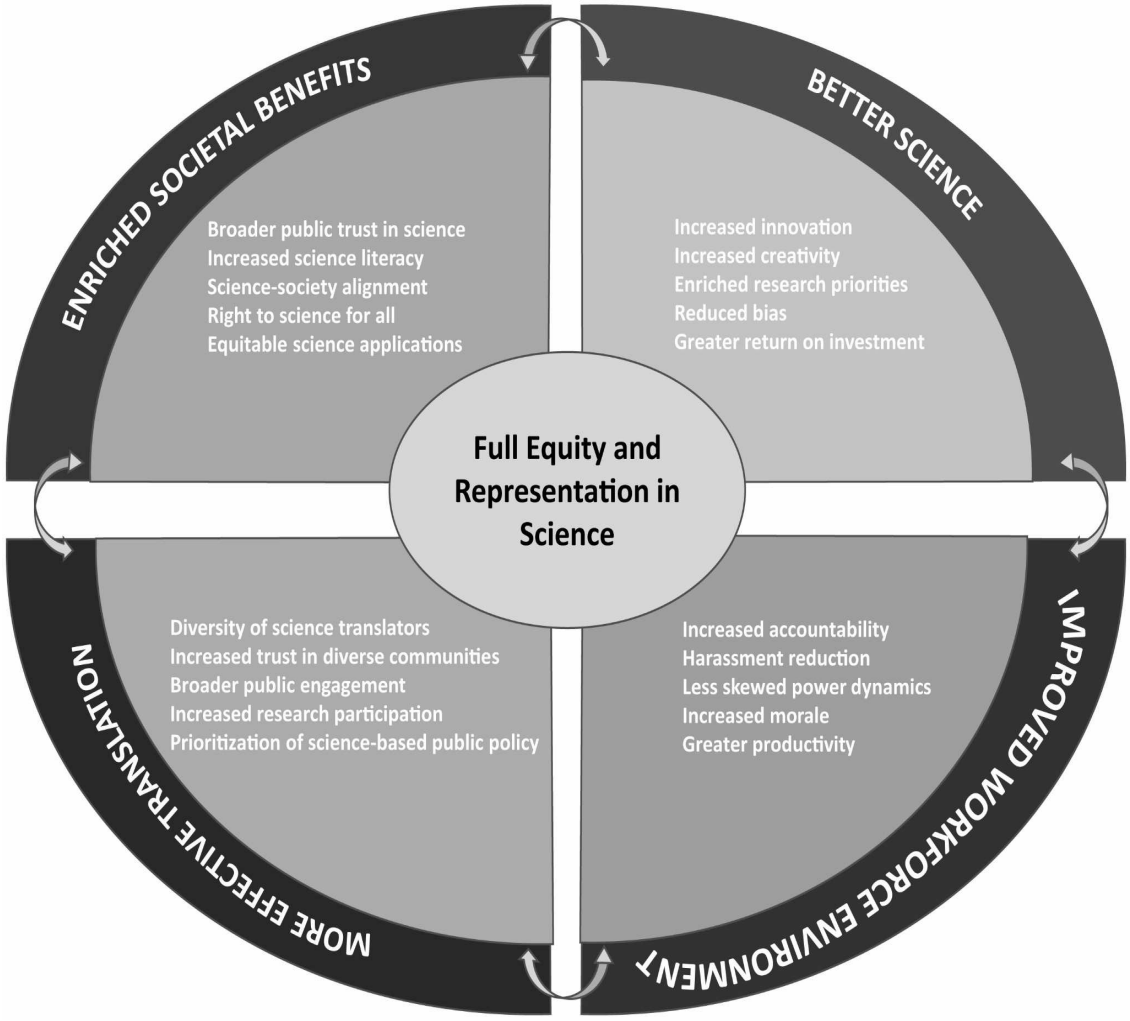

Figure 1

Benefits of Full Equity and Representation in Science (Graves et al., 2022)

Kozlowski et al. (2022) also outline several additional scientific and societal benefits to increasing diversity in science. These include increased sales and profits in industry, increased volume of citations, and enhanced innovation.

Whether overt or more nuanced; whether through direct abuse, or neglect, or by exclusion, the problem of oppression in science is well substantiated. It affects

marginalised students' experiences in the science classroom. It affects their experiences as future scientists and citizens. And it affects the outputs of science systems. Efforts to confront and redress this issue should therefore be pursued for the benefit of students and society.

2.2 Anti-Oppressive Teaching

The proceeding section provides only a brief introduction to oppression in science. It is not exhaustive, but it still makes clear that this issue is complex and multi-faceted. As such, it will require the efforts of a host of institutions and stakeholders to rectify. Dedotsi and Paraskevopoulou-Kollia (2019) argue that educational institutions such as schools and universities, being the main vehicle of socialization, are one of the most important places for this anti-oppressive work. This study focused on the role of classroom science teachers and how they address injustices by implementing anti-oppressive teaching practices.

As mentioned in the introduction, there are numerous pedagogical movements under various names which are aimed at promoting equity in education. Lehr (2007) suggests that many of these movements attempt to “address issues related to social diversity by celebrating differences". They are critical that these efforts ignore the social inequalities attached to these cultural differences, “marginalizing the difference that matters - who has power and who does not?” (Lehr, 2007). Because an imbalance of power and privilege is central to the concept of oppression, it must be central to anti-oppressive work. Therefore, this study emphasizes the movement of “anti-oppressive

teaching." Stavrou and Miller (2017) describe anti-oppressive teaching as a pedagogical approach which is focused on challenging the root causes of oppression, understanding how schools play a role in perpetuating inequality, and finding strategies to counter educational discourses that position western voices and knowledge as superior while pushing other identities and ways of knowing to the margins.

All members of our society have a duty to end oppression, but teachers, in particular, have a responsibility to be advocates for students, including those from marginalized communities (Gardner & Kelly, 2008; Stewart, 2010). Science teachers also have a responsibility to represent science, science programs of study, and science workplaces in an authentic and honest way which includes acknowledging the oppression within these spaces. Furthermore, there is abundant research demonstrating the importance of school climate on student self-esteem, self-concept, and even learning (Cohen, 2006; Kumashiro & Ngo, 2007). Students can not learn in an environment in which they do not feel safe and validated. Snapp et al. (2015) discuss how anti-oppressive teaching practices benefit all students, not only those of marginalized identities.

2.2.1 Anti-Oppressive Science Teaching Practices

To truly enact change in science and science education, teachers will need to invoke a multitude of different anti-oppressive practices. There is abundant literature that examines anti-oppressive and related teaching theories (Blakeney, 2005; Brown, 2017; Lehr, 2007; Lodge, 2021; Rezende & Ostermann, 2020). However, literature that explores tangible strategies or practices that classroom teachers can enact is scarce.

Blakeney (2005) maintains that this is sometimes intentional as it is important to "avoid the reduction of Critical Theory to method and technique" (p.127). The Stanford Encyclopedia of Philosophy describes Critical Theory as "a family of theories that aim at a critique and transformation of society by integrating normative perspectives with empirically informed analysis of society's conflicts, contradictions, and tendencies" (Celikates & Flynn, 2023). Blakeney (2005) notes that teachers must ground themselves in the ideology as that ideology provides a method for recognizing and addressing oppression. In the following section several notable contributions to the literature of anti-oppressive teaching are explored. These contributions range from broad theory-based principles to more actionable strategies. This does not represent an exhaustive inventory and it is recommended that school boards, schools, and teachers work with marginalized communities to develop plans of action to address oppression which is responsive to their own local context (Stewart, 2010).

In *Toward a Theory of Anti-Oppressive Education* Kumashiro (2000) reviews the collective literature and conceptualized four general components of anti-oppressive teaching practices. They go on to describe and critique each approach and explain how each can be valuable in achieving different goals. Ultimately Kumashiro advocates for what they call an amalgam of the four approaches (2000). Kumashiro's four approaches include:

1. Educating for the Other - Improving the experience of those students that are oppressed and creating safe spaces.
2. Educating about the Other - Incorporating representation which normalizes differences. This should include overt lessons which address differences as well

as embedding diversity throughout lessons. They suggest including role models and guest speakers and exploring the life histories of scientists.

3. Education that is critical- teaching a critical awareness of oppressive structures and ideologies.
4. Education that changes- challenging biases and recognizing partiality in curriculum, teachers, and students. They suggest this requires working through crises and supposes a commitment on the part of educators and researchers to subversive views of the purposes of education and of the roles and responsibilities of teachers.

In this context, the word "other" is used to refer to groups traditionally marginalized in society (Kumashiro, 2000). In addition to these four broad approaches, Kumashiro also stresses the importance of a practice that is "fluid" and "situated" explaining that teachers must consistently reflect on and adapt their practice to meet the needs of their students (2000).

Nearly a decade later after Kumashiro, Thompson et al. (2021) set out a framework for critical science teaching that consists of 4 principles which correspond closely with Kumashiro's original approaches. Thompson et al.'s principles are outlined below (2021, p.59-63).

1. Recognizing our own and other's worlds and developing critical consciousness
2. Learning about and prioritizing students' communities and cultures
3. Designing for each student's full participation in the culture of science
4: Challenging the culture of science through social and restorative justice

Thompson et al.'s first principle aligns with Kumashiro's "Education that is Critical". The second principle aligns with "Education about the Other", the third with "Education for the Other" and the final principle aligns with "Education that Changes". While Thompson et al.'s principles conform closely to Kumashiro's approaches, they are presented in a way that provides additional insight. For each principle, Thompson et al. share brief but concrete examples of science lessons that wembody the objective. For the first principle they discuss a project which led science teachers to consider their own positionality and privilege relative to their students who live in areas with significant sound pollution. For the second principle they describe a community action project where students engaged with a local farm. The third principle was exemplified as students produced a science based film in which they each encorportaed their own native language. Finally, fitting with the fourth principle, they describe a cross-curricular biology and language arts lesson which cronfronts the bioethical issues of HeLa cells. Thompson et al. (2021) also include tips for teachers and a table of critical questions to support planning to help teachers self-assess their anti-oppressive teaching practices.

Looking toward more detailed, specific strategies for anti-oppressive science teaching, The National Science Teaching Association (NSTA) has published several resources. This includes a resource to support gender equity in science education (NSTA, 2019) and another on building an anti-racist science classroom (Bakshi, 2020). Bell and Bang (2015) have also developed a wealth of publicly available STEM teaching tools that focus on anti-oppressive teaching. This collection includes topics such as dismantling systemic racism, indigenous science, and how to include gender, sex, and sexuality as

part of inclusive science teaching (Bell & Bang, 2015). Bell (2019) also authored an article which explored teacher learning related to equitable science education. Within that article, they include a list of proposed equity and justice projects for science education:

1. Engage in Culture-based Pedagogies: support expansive learning pathways for learners through culturally responsive, sustaining, and resurgent pedagogies
2. Support Diverse Sense-Making: build educator capacity and educational resources to leverage the diverse intellectual resources learners bring to educational environments
3. Disrupt Ableism: promote a cultural model of ability by leveraging and extending beyond universal design
4. Promote Place-based Learning & Ecological Caring: support science learning in outdoor settings and help people learn to engage in ecological caring practices in support of socio-ecological thriving and multi-species justice
5. Centre Racial Justice: build capacity for counter-racist pedagogies; promote critical consciousness and responses around systemic racism
6. Arrange for Crossage, Family & Community Science Learning: dismantle the age segregation associated with settler-colonial schooling and normalize a focus on cross-age and cross-generational learning communities, leverage families as co-designers of education, make science education accountable to community goals
7. Design Course Sequences Using a Range of Meaningful Phenomena: design instruction where learners routinely investigate and act upon natural phenomena that have social gravity for them, their community, and society— including justice-centered phenomena

(Bell, 2019)

Representation is another important aspect of anti-oppressive teaching often cited in the literature. Promoting the achievements of diverse scientists, especially those whom science history has erased, and offering diverse role models and mentors, as well as diverse perspectives, is key. Thurber et al. (2019) discuss the need for teachers to choose classroom content (text, media, activities) that represents diverse identities and perspectives, and Snapp et al. (2015) recorded that Queer youth claim that when they could see themselves reflected in the curriculum, they felt more hopeful about their own futures. Lewis et al. (2016) note several independent studies in which interventions promoting a sense of belonging among marginalized groups resulted in increased academic performance and physiological health.

It is paramount that historical and ongoing oppression is acknowledged and overtly challenged in the science classroom. Any effort to incorporate multicultural perspectives and celebrate diversity is hollow unless the root issues of power and privilege are addressed. Students have been exposed to these oppressive biases throughout their lives both within the school system and outside of it. Kumashiro (2002) explains that "learning in anti-oppressive ways involves un-learning or questioning what students already know." Jegede and Aikenhead (1999) promote integrating discussions about science with history, morality, justice, equality, freedom, and spirituality. Addressing these issues directly also helps students develop the skills to think critically about the world and social justice. Thurber et al. (2019) promote overt discussion of oppression as it allows space for the student to engage in reflexivity.

The above-noted strategies form some of the core tenets of anti-oppressive teaching. Jegede and Aikenhead (1999) provide additional strategies, as do others. A more extensive outline of teacher practices are presented in Table 1 of chapter 2. However, it is important to recognize, as Kumishiro (2002) highlights, that there is no one way to be anti-oppressive educators. Teachers must work collaboratively with their communities, colleagues, and students to develop resources and strategies which are responsive to the needs of their local and current context (Stewart, 2010; Thurber et al., 2019).

2.2.2 Resistance to Anti-Oppressive Science Teaching

Oppression of marginalized identities within science is well-documented as both a historic and ongoing issue. At the same time there is a clear indication from education experts and schools that promoting inclusion and safe and caring school climates is a priority (Goverment of Newfoundland and Labrador). However, some educators and administrators are resistant to direct anti-oppressive education and Stewart (2010) contends that this is even more so in the field of science education. In their examination of Queer-inclusive curriculum for example, Snapp et al. (2015) found math and science instruction was the least inclusive. This is thought in part to be a residual effect of science's perceived objectivity and disconnect from social issues. There is, however, an ongoing paradigm shift, with increased recognition of science as a human product that develops within societies and cultures and as such, is subject to human errors and distortions (Stewart, 2010).

Many educators do not value anti-oppressive teaching because they do not recognize the oppression (Solomona et al., 2005). Thurber et al. (2019) explain that some teachers believe racism (and other forms of oppression) to be a thing of the past. For many people, their operational definition of oppression is limited only to overt, intentional efforts that seek to harm and exclude, and they fail to recognize more nuanced forms of oppression. Some also believe that oppression is only relevant to those who are oppressed. Based on an interview study in northern Saskatchewan, Aikenhead and Huntley (1999) analyzed the teachers' views of Western science and Indigenous knowledge, as well as their teaching practices. The authors found that non-indigenous teachers did not recognize the role of Western science and "progress" in the oppression of Indigenous people, and they did not acknowledge a connection between their science teaching and Indigenous worldviews. Tomkins (2002) reported similar observations concerning attitudes in teaching Mi'kmaq students in Nova Scotia.

In instances where educators do acknowledge the issue of systemic oppression in science and its connection to their students, they may still be hesitant to address it in their classrooms. Kelly (2020) contends that resistance is especially heightened around contemporary issues or issues that manifest locally. Stavrou and Miller (2017) explain that some educators feel uncomfortable in acknowledging racism because it is seen as too controversial. Wing Sue et al. (2009) discuss how, among white faculty, fear is a significant obstacle in approaching anti-oppressive teaching. According to Wing Sue et al. (2009) teachers fear revealing personal biases and prejudices or losing classroom control; they also cite an inability to understand the dynamics of difficult dialogues and a

lack of knowledge and skills to intervene properly. This fear of not knowing how to properly address such important issues can have a paralyzing effect which leads teachers to avoid the issues (Samuels, 2018; Surette, 2019). However, Peterson counters this as he writes: "What a teacher does not do in the classroom is just as important as what the teacher does: What voices are silenced in the curriculum? What histories and practices are marginalized? Are controversies recognized or made invisible?" (Peterson, 1994 as cited in Lehr, 2007, p.20). Teaching is never neutral and when educators fail to acknowledge and work to dismantle systems of oppression, they are upholding them.

2.3 A Theoretical Framework for Anti-Oppressive Science

This study was framed through a lens of critical pedagogy. Critical pedagogy is a term used to describe what emerges when critical theory encounters education (Kincheloe & Steinberg, 1997, p. 24). Critical Theory is defined as a school of thought that focuses on the examination and critique of society and culture (Moisio, 2013). Moisio claims Critical Theory has two distinct elements. The first is that empirical study and philosophical analysis should be brought together to build a detailed understanding of a phenomenon under study. The second is that critique should be founded on the needs of those marginalized by the existing system. A notable distinction is that while traditional theory "merely reflects the current situation," critical theory seeks to change it (Crotty, 1998, as cited in Troudi, 2020). Brazilian thinker Paulo Freire is widely regarded as laying the foundation of critical pedagogy with his application of critical theory to education, particularly in his work "Pedagogy of the Oppressed" (Freire, 2005). Freire rejected the neutrality of education, framing teaching as an inherently political act. He

problematized what he saw as a banking model of education and instead emphasized the need for critical awareness or "conscientization" together with "praxis" - reflection and action.

Critical pedagogy has an important role in science education. Lodge (2021) claims:

> Locating science education within the traditions of critical pedagogy allows us to interrogate some of the historical, theoretical, and practical contradictions that have challenged the field and to consider science learning as part of a wider struggle for social justice in education (p. 611).

The importance of critical pedagogy in science is further supported by a host of other studies and writers (Aikenhead, 2006; Barton, 2001; Galamba & Matthews, 2021; Longbottom & Butler, 1999; Sheth, 2019). Importantly, critical pedagogy does not end with theory. Freire and others are clear that it relies on praxis and translating knowledge into action (Freire, 2005; Galamba & Matthews, 2021). However, Troudi (2020) cautions that it is difficult to identify one "template" of critical pedagogy since the "critical" would, in its very nature, resist such stringent compartmentalization. hooks (2014) echoed this sentiment, claiming that a blueprint for critical pedagogy practice would undermine the need to recognize each classroom as different. Instead, strategies must be constantly changed, invented, and reconceptualized to address each new teaching experience (hooks, 2014).

While mindful to resist subscribing to a blueprint for critical pedagogy, this study requires a lens through which to examine the practices of classroom science teachers.

Kumishiro's (2000) approaches to anti-oppressive teaching, while not overly prescriptive, provide a strong framework for this work. Through a review of relevant literature, anti-oppressive science teaching practices identified by various scholars were conceptulaized under the four broader categories devised by Kumishiro (2000); (i) Education for the other, (ii) Education about the other, (iii) Education that is critical, and (iv) Education that changes. Table 1 below outlines each of these practices. It should be noted that several teaching practices could be conceived as fitting with more than one of Kumishiro's approaches. This table is not exhaustive nor prescriptive but simply provides a framework with which to examine participant teacher practices.

Table 1

Anti-Oppressive Teaching Practices Under Kumishiro's Four Approaches

Approaches (Kumishiro, 2000)	**Example Practices**
Education For the Other	○ Create a safe & positive learning environment that values all learners. Employ classroom practices, structures, and expectations that are inclusive and culturally relevant (Chowning et al., 2022; NSTA, 2019; Saunders & Wong, 2020) ○ Build relationships & bridge connections between school, community, & family (Chowning et al., 2022; Morrison & Bell, 2018) ○ Develop strategies to prevent and disrupt biases, stereotypes, microaggressions, & deficit thinking (Kelly, 2012; NSTA, 2019; Saunders & Wong, 2020) ○ Encourage all learners to pursue science opportunities & consider science careers (NSTA, 2019) ○ Employ intentional strategies to ensure lessons, labs, activities, and assessments are accessible to all (Abu- Boateng, 2019; Bell, 2019) ○ Honour learners' perspectives & voices. Provide meaningful opportunities for students to contribute (hooks, 2014).

Education About the Other	○ Increase representation. Centre the histories and voices of marginalized groups & select resources that emphasize their contributions to science (Morrison et al., 2017; NSTA, 2019; Wong & Saunders, 2020) ○ Offer diverse role models & mentors through resources, posters, guest speakers, etc. (Bakshi, 2020; Long et al, 2021) ○ Honour diverse epistemologies. Build connections between Indigenous ways of knowing, local and cultural knowledge, and Western science. (Bell, 2019; Spang & Bang, 2015)
Education that is Critical	○ Create a culture of discourse on social justice and employ a dialogical process in lessons (Bakshi, 2020; Santos, 2009) ○ Create space for teachers and students to interrogate their own perceptions of science and scientists. Address positionality, bias, & privilege (Morales-Doyle, 2017; Morrison & Bell, 2018; Snively & Williams, 2018) ○ Employ lessons which explicitly address & challenge oppression in current and historical science practices (Long, 2019) ○ Engage students & communities to select appropriate, relevant socioscientific issues to engage with in meaningful ways (Long et al., 2021; Santos, 2009) ○ Develop norms for discussing controversial or sensitive topics and discuss tools for respectful and effective discussion (Morrison et al., 2017)
Education that Changes	○ Develop lessons that centre students, invoke agency, and promote participatory culture and collaboration (Davis et al., 2015, Santos, 2009) ○ Practice using science explanations & data to analyze & challenge bias and disrupt oppressive social and political structures (Long, 2019) ○ Make science education accountable to community goals. Engage students in relevant action projects where they feel empowered to make real-world change now rather than simply preparing for their future. (Bell, 2019; Morrison et al., 2017; Santos, 2009; Upadhyay et al., 2020) ○ Facilitate navigation within & across multiple epistemologies. Partner with Indigenous elders, storytellers, and community members to promote diverse perspectives and ways of knowing (Spang & Bang, 2015) ○ Offer learning that is land and place-based & engage in ecological caring practices (Bell, 2019; Spang & Bang, 2015)

Chapter 3: Methodology

This chapter outlines the methodology for this research study. It begins by defining the research context and describing the research participants. It then goes on to outline the research design, including a rationale for the use of a mixed methods approach. The data collection process is explained followed by a description of the data analysis processes employed. Finally, measures used to validate the data are explained.

3.1 Research Context

This study focuses on intermediate and senior high science teachers within the Newfoundland and Labrador English School District. This region consists of over 250 schools with over 63,000 students (Government of Newfoundland and Labrador, 2024). The location selected for this study is based on two factors. Firstly, it is the region most relevant to the researcher as it is the region in which they have taught for the past decade and secondly, it is a region in which data and research of this nature is deficient.

3.2 Participants

The population assessed in this study is intermediate and senior high science teachers within the Newfoundland and Labrador English School District. Though this study relates to marginalized communities, it should be noted that it did not directly influence or impact those communities. This was a passive study which collected data on ongoing practices only and did not seek to impact participants or students directly.

3.2.1 Participant Recruitment

Teachers were recruited to complete an online questionnaire and/or participate in semi-structured interviews. A recruitment letter and questionnaire link were distributed to intermediate and senior high science teachers in the Newfoundland and Labrador English School District through the NLESD science program specialist and through school principals via school secretaries. These avenues were used in an attempt to maximize the sample and to ensure the representation of the diversity of the population. It should be noted that recipients of the email were not obligated to respond and certain individuals, namely those who practice anti-oppressive teaching or those who belong to marginalized communities, may have been more inclined to engage. As such, the participants do not represent a truly random sample. At the end of the questionnaire a link directed participants to a separate form where teachers interested in participating in the interview component of the study could provide their email address. This process ensured the anonymity of the questionnaire data was maintained. All teachers who submitted their email addresses were contacted for interviews and no selection was needed.

3.2.2 Participant Demographics

The questionnaire was completed by 42 science teachers. Table 2 shows the demographic data of those respondents, including employment status, years of experience, and self-identification with marginalized identities. Though the questionnaire had a modest response rate, it did capture a wide demographic of teachers, including substitute, replacement, and permanent teachers, as well as one recently retired teacher.

The majority of participants were permanent, tenured teachers (68.3%) and had taught for over ten years (52.4%). Participants were asked to indicate all of the science courses they had taught within the past three years. From this, it was confirmed that the questionnaire captured all intermediate and secondary science courses currently offered within the Newfoundland and Labrador School District. It should be noted that many respondents omitted the section on identity or selected "prefer not to disclose." A small majority of respondents self-identified as women (52.4%), and several indicated other marginalized identities.

Table 2

Self-Reported Demographic Data of Questionnaire Respondents

	Study Group	
Variable	n	%
Employment Status		
Substitute	4	9.5
Replacement	7	16.7
Permanent probationary	2	4.8
Permanent tenure	28	66.7
Retired	1	2.4
Years Experience		
0-4 years	22	52.4
5-9 years	9	21.4
10+ years	11	26.2
Self-identification		
Woman	22	52.4
Queer/ 2SLGBTQ+	5	11.9
Disabled	2	4.8
Indigenous	3	7.1
Racialized minority	1	2.4

Given the small number of interview participants, individual demographic information is not disclosed to protect anonymity. However, the demographic data of the five interview participants dis reflect a similar range as seen in the questionnaire demographics.

Demographic data were collected to validate that questionnaire responses were representative of a range of NLESD teachers. It was not the intention of this study to

examine correlations between demographic characteristics and teachers' attitudes on or use of anti-oppressive teaching. This may however be an interesting question for future research.

3.3 Research Design

In this research study, a mixed-methods approach was adopted. Mixed methods design integrates both quantitative and qualitative data collection methods within a single research study or a series of studies to improve saturation and validity (Creswell, 2012). Recognizing that different data sources each possess distinct advantages and drawbacks, the mixed methods design aims to leverage the strengths of each data type while neutralizing the non-overlapping weaknesses (Creswell & Clark, 2007, p. 62). According to Morse (1991) the intention of this approach is to gather distinct but complementary data on the same research topic. The literature also suggests that this technique is appropriate for a situation in which a researcher seeks to confirm or enrich quantitative results with qualitative insights (Creswell, 2012). Based on these criteria this approach was deemed suitable for this study. Scholars in the area of mixed-methods research further classified mixed-methods design into specific typologies that are useful for providing researchers with an organizational structure to frame their work to address specific research questions asked (Creswell, 2013; Tessie & Tashakori, 2006). They also describe many of the criteria used to identify a specific mixed-methods typology, such as the number and type of methodological approaches (quantitative and qualitative), priority and weightage of methodological approach, stage of integration of methodological

approaches, among others (Teddlie & Tashakkori, 2006, p. 13).

This study design employs triangulation in a convergence model (Creswell, 2013, pp.62-64). According to Creswell (2013) triangulation is the most common and well-known approach to mixed-methods design. The specific type of triangulation used in this study is the convergence model which is the traditional model of mixed methods triangulation design (Creswell, 2007). Within this design, the researcher collects and analyzes quantitative and qualitative data separately. Data is then converged during the interpretation by comparing and contrasting the results of each input (Creswell, 2007). This method is used to validate and corroborate results between data types. Figure 2 below illustrates the steps of data collection, analysis, and interpretation as carried out in this study.

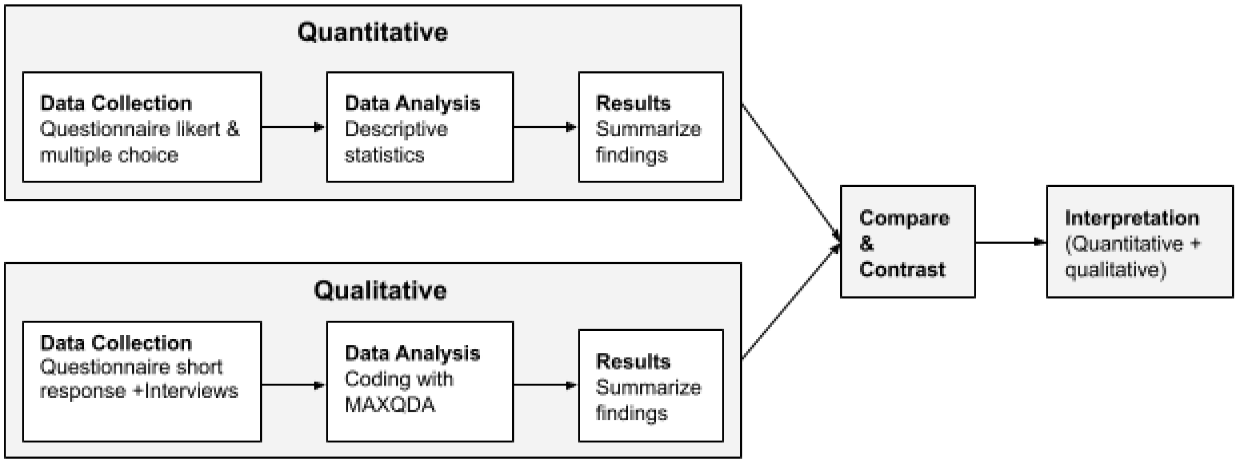

Figure 2

Study Workflow in Triangulation Design: Convergence Model

3.4 Data Collection

Whitt (1991) and Tite (2010) suggest that researchers combine various data collection techniques in order to make the most of the strengths and to reduce the impact of the limitations of each method. Two data sources were centred in this study: A brief, 5-10 minute anonymous digital questionnaire and semi-structured ~30-minute interviews conducted via Google Meet. Interviews are often a primary instrument of data collection in qualitative research (DiCicco‐Bloom & Crabtree; Tite, 2010). However, due to constraints to teachers' availability and schedules, it is not practical to complete interviews with a very large number of participants. For that reason, data collection in this study began with a widely distributed digital questionnaire. From there, a sub-sample of teachers were invited to participate in semi-structured synchronous interviews. The questionnaire provided both quantitative and qualitative data. From a practical perspective, and considering the limited time and resources, the questionnaire allowed for a larger sample size which would paint a broad picture of current views and practices. Interviews provided more rich, detailed qualitative data which was used to verify and give context to the trends seen in the questionnaire. Interviews also provided more detail regarding the factors that facilitated or hindered their use of anti-oppressive teaching. In this way, the mixed method design led to a more complete understanding than any one method could provide alone.

3.4.1 Quantitative Data Collection

Quantitative data was collected through a brief digital questionnaire (3-5 minute),

which was anonymous, and completed via Google Forms. This application was employed because it is free and easily accessible. It is also familiar to target participants as it is part of the Google Suite of tools promoted and used throughout the school district. It is flexible as a variety of question types can be included and it also allows for anonymity. No existing questionnaires relevant to the research questions were identified and so the questionnaire for this study was developed by the researcher grounded in the theory and literature as outlined below. It was further informed by their own experience teaching various science curricula over the past decade in the local context.

The questionnaire included basic demographic information, such as employment status and number of years of teaching experience; the questionnaire also asked participants whether they identify as a member of any of the marginalized groups referenced in the study (women, racialized minorities, Indigenous people, gender and sexual minorities, and people with disabilities). Kelly (2017) contends that this type of sensitive information should only be collected when necessary for the research purpose. And, in this research study, it is reasonable to expect that the identities of respondents may be relevant to the study as those who identify as members of a community marginalized in science may likely have different perspectives about the importance of anti-oppressive teaching practices. To balance the need for sensitivity with the need for contextualized data, this question was specifically worded to ask only if participants identify with any of the groups listed. It did not ask participants to disclose their race, gender, etc. Also, a response option of "prefer not to disclose" was provided. The questionnaire was completed anonymously to promote unbiased responses. If interested,

participants were directed to a separate link to provide their email contact to participate in the follow-up interview.

The questionnaire included a combination of multiple-choice, Likert scale, and short, open-response questions about teachers' views on and use of anti-oppressive teaching. The use of the Likert scale allowed more complex topics such as teachers' views on oppression to be broken down into manageable responses and allowed common trends between participants to be more readily apparent (Bhandari & Nikolopoulou 2020). An effort was also made to use question types that were more user-friendly, allowing participants to quickly reflect and select a response rather than having to develop and articulate their own ideas. This helped in reducing the time commitment of the questionnaire which helped to maximize the response rate.

The questionnaire also included some open-ended questions that aimed to offfset the limitations of Likert scale questions. For example the terms used for Likert scale responses can sometimes be interpreted differently across participants. The word “frequently” may mean different things to different participants. To account for this, follow-up, open-edned questions provided participants with the opportunity to expand on their responses.

3.4.2 Qualitative Data Collection

As mentioned above, in addition to multiple choice and Likert scale questions which yielded quantitative data, the questionnaire also included some short response questions that provided qualitative data. These questions included: “Within the science

courses you teach, which units and topics do you feel provide opportunities to address issues of oppression?" In addition, participants were given an opportunity to share "any additional thoughts or reflections that you would like to share that were not invited in the above questions". Interviews were then conducted to provide more context and a richer understanding of the data. As suggested by Tite (2010), the semi-structured interview consisted of questions which were open-ended and required more than a yes-no response. The same questions were asked of all respondents.

Interviews were conducted synchronously via video conferencing. Conducting interviews via video conference was preferred over in-person interviews because it removed barriers associated with travel and made participation accessible to teachers throughout Newfoundland and Labrador. The video conferences were conducted using Google Meet. This specific application was chosen as it is a free application that is accessible and familiar to participants as a result of its wide use throughout the school district. The duration of the interviews was approximately 30 minutes. This timeframe was chosen to fit within teachers' prep periods during the regular school day which was anticipated to promote participation. Interviews were conducted with only the participant and lead researcher present. The researcher in this case is also an intermediate-secondary science teacher. The symmetry achieved through this peer relationship was expected to help foster a safe environment where participants could respond to questions in an honest manner. Interviews were audio-recorded and transcribed verbatim by the researcher.

Interview transcripts were provided to the participants for member-checking. It was acknowledged that this research study involved topics that might be sensitive to

some participants. For members of marginalized communities, it may be difficult to talk about past experiences. In other cases, teachers may feel self-conscious in admitting they have not taken any anti-oppressive action. Respondents may also feel uncomfortable discussing the reasons for their inaction including lack of understanding or perceived lack of administrator support. For this reason, participants had the opportunity to review transcripts and provide clarification on anything that they felt, upon reflection, had been missed or misrepresented. It was thought that having the knowledge going into the interviews that they would have the opportunity to review and redact where necessary may have allowed teachers to feel more comfortable in giving honest responses during the interview process. When reporting the findings of the study, the participants were assigned a pseudonym for the purpose of maintaining anonymity.

3. 5 Data Analysis

Quantitative and qualitative data were analysed separately in keeping with the convergence model of mixed methods research. The software MAXQDA was the primary tool used for data organization and analysis in this study. This software was chosen as it is a leading product for mixed methods study (Guetterman & James, 2023). It was also preferred as it was readily available to the researcher. The sections below detail the quantitative and qualitative data analysis procedures that were carried out in this study as well as the process used for the convergence of the data streams post-analysis.

3.5.1 Quantitative Data Analysis

Quantitative data analysis was carried out through a structured approach whereby

data obtained from the questionnaire were reviewed through a process of scoring individual responses. This method facilitated the generation of descriptive statistics, a fundamental step as outlined by Creswell (2013) in allowing the observation of trends and patterns (pp. 175-195). The analysis primarily focused on calculating the mean, which represents the average response to each questionnaire prompt and is illustrative of the central tendency of the data. Additionally, the standard deviation was computed to gauge the dispersion or variability of responses around the given mean, reflecting the level of agreement among participants. Data with lower standard deviation would therefore indicate a stronger consensus among respondents.

The scope of quantitative data analysis in this study was confined by the sample size. There were not a sufficient number of questionnaire respondents to support more thorough statistical analyses, such as inferential statistics, which could have allowed for hypothesis testing or the establishment of cause-and-effect relationships. It might have been interesting for example to explore potential relationships between participants' years of experience and attitudes on anti-oppressive teaching. Ultimately the decision to limit the analysis to mean and standard deviation was made to ensure the integrity and reliability of the findings under the constraints of the available data.

3.5.2 Qualitative Data Analysis

Qualitative data analysis was carried out using a grounded theory approach (Creswell, 2013, p.422-429). Interview transcripts were organized and coded using the software MAXQDA. The theoretical framework outlined in Table 1 in Chapter 2

provided the lens through which data was examined and categories were established based on this. In the first phase of analysis, known as open coding, interview transcripts were read and re-read to identify words and phrases that aligned with each of the pre-established categories. These words and phrases were selected and flagged using the tools available in MAXQDA. Next, axial coding was used to identify relationships between categories. Those categories were then clustered into meanings and eventually used to formulate propositions.

3.5.3 Convergence of Data

Following separate analysis of each data type, the results were mixed via a convergence model as shown in Figure 2. This involved a detailed examination and comparison of the findings from each data stream relevant to each of the three research questions. The weighting of the data sources in this study emphasizes the qualitative questionnaire and interview data. These sources provided more rich detail and context. Therefore, prioritizing this data fits with the purpose of the study which seeks to establish a meaningful snapshot of the state of anti-oppressive science teaching in Newfoundland and Labrador.

Chapter 4: Findings

The findings of this study are provided below and are organized by topic and data type. The three major topics addressed in this study, in order, are (1) Teachers' views of oppression and anti-oppressive teaching in science, (2) Teachers' Practices Related to Anti-oppressive Teaching, and (3) Factors that Influence Teachers' Implementation of

Anti-oppressive Teaching. Within each topic, the quantitative data is communicated first. This data was obtained from Likert scale responses to the questionnaire. Following this, the qualitative findings are described. Qualitative data is based on open-ended response sections of the questionnaire as well as interview responses. The pseudonyms Alex, Drew, Jaime, Jordan, and Maggie have been assigned for interview participants.

4.1 Teacher Views about Anti-Oppressive Science Teaching

4.1.1 Quantitative Findings

The first section of the questionnaire assessed teachers' views on oppression in science and on anti-oppressive science teaching. Participants were asked to rate the extent to which they agreed with eight statements on a Likert scale with values ranging from 1(strongly agree) to 5 (strongly disagree). The data is shown in Table 3 and Figure 3 below.

The first four statements accessed teachers' perspectives on equity and oppression in science. Responses in this section were contradictory. The majority of teachers agreed or strongly agreed that science is accessible to all (52.4%) and benefits all equally (50.0%). However, most teachers also agreed or strongly agreed that science has historically upheld inequality and/or oppression (65.8%). A small majority also agreed that science continues to uphold inequity and/or oppression (39.0%).

When asked about their views on anti-oppressive teaching, there was a much clearer consensus. Most teachers agreed or strongly agreed that they feel responsible for discussing or confronting inequity and oppression in their science classroom (64.3%);

Only 7 respondents (16.6%) disagreed. Those same 7 respondents agreed to the statement "I don't think issues of oppression should be addressed within science classes" while the majority of teachers (50.0 %) strongly disagreed with that statement and a further 19% disagreed.

Respondents were most closely aligned in their views on the current NLESD curriculum. Only 14.6% of respondents agreed with the statement "Existing science curriculum and resources include diverse voices and perspectives from marginalized communities". Only 7.2 % agreed with the statement "Existing science curriculum and resources support the inclusion of anti-oppressive lessons" while 38.1% disagreed and 21.4% strongly disagreed.

Table 3

Teachers Views about Anti-oppressive Science Teaching

	Response Frequency (n) And Percentage (%)					Mean	SD
Statement	1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree		
Science is equally accessible to all people.	5 11.9	17 40.5	10 23.8	5 11.9	5 11.9	2.71	0.99
The products of science benefit all people equally.	8 19.0	13 31.0	7 16.7	8 19.0	6 14.3	2.79	1.17
Science has historically upheld inequity and/or oppression.	14 34.1	13 31.7	6 14.6	3 7.3	5 12.2	2.32	1.10
Science currently upholds inequity and/or oppression.	3 7.3	13 31.7	10 24.4	12 29.3	3 7.3	2.98	0.91

I feel responsible for discussing or confronting inequity and oppression in my science classroom.	14 33.3	13 31.0	8 19.0	3 7.1	4 9.5	2.29	1.03
I don't think issues of oppression should be addressed within science classes.	2 4.8	5 11.9	6 14.3	8 19.0	21 50.0	3.98	1.03
Existing science curriculum and resources include diverse voices and perspectives from marginalized communities.	0 0	6 14.6	14 34.1	13 31.7	8 19.5	3.57	0.83
Existing science curriculum and resources support the inclusion of anti-oppressive lessons.	1 2.4	2 4.8	14 33.3	16 38.1	9 21.4	3.71	0.77

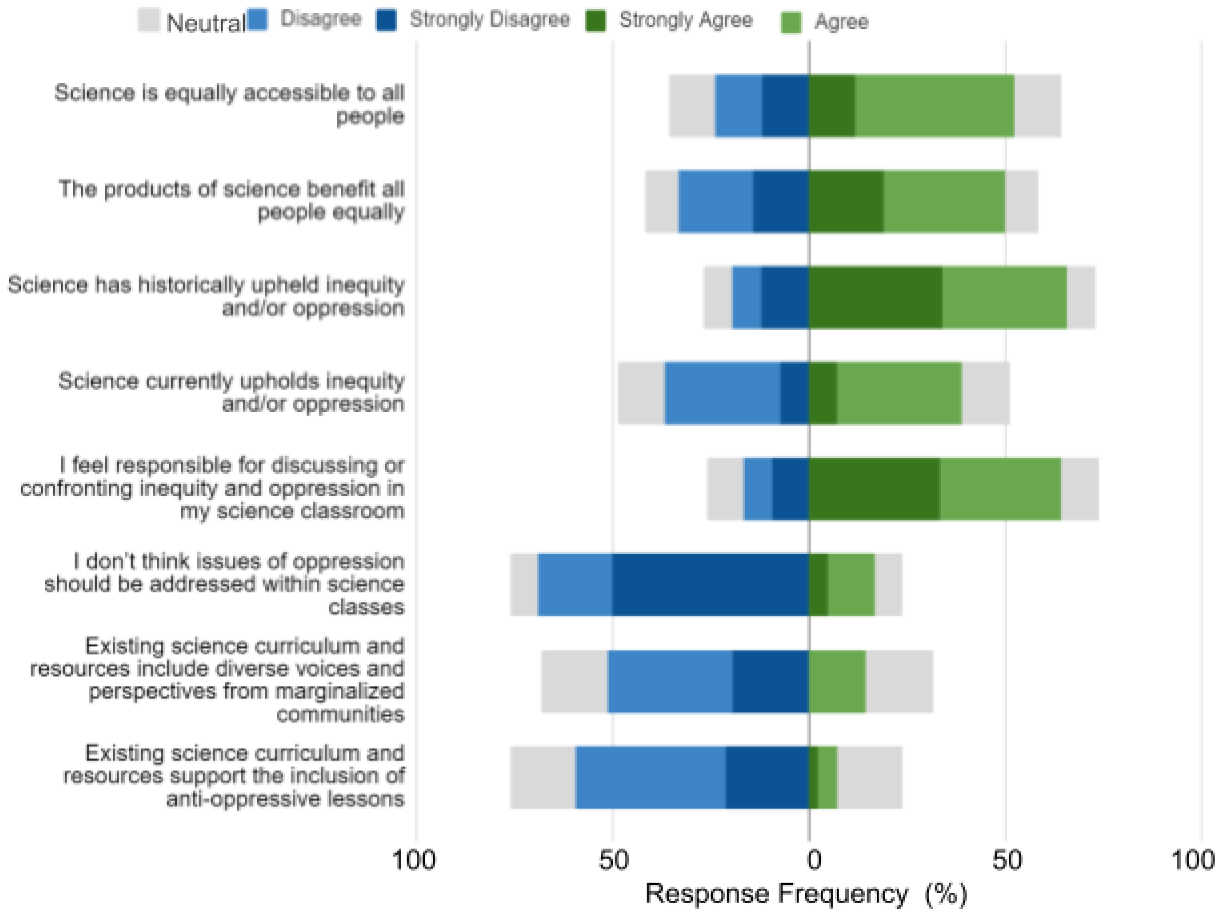

Figure 3

Teacher's Views On Anti-oppressive Science Teaching

4.1.2 Qualitative Findings

This section will first review the qualitative data gathered from short response elements of the questionnaire and will then summarize the qualitative data obtained from interviews.

Questionnaire

Respondents were asked, "Within the science courses you teach, which units and

topics do you feel provide opportunities to address issues of oppression?". The responses showed a stark contrast in teachers' attitudes toward anti-oppressive teaching.

Some teachers expressed a belief that science courses are not the appropriate space for anti-oppressive teaching. One commented, "It holds little to no relevance to the material we teach. Such discussions should be saved for Social Studies where social issues are meant to be covered". Another wrote that it is not relevant and that "science is objective and doesn't care about feelings, only facts". A third claimed "I'm just here to make science interesting and fun. We do not discuss any socio-economic factors in Science. This may be something addressed in Social Studies." Others did not necessarily object to covering anti-oppressive lessons in science but did not themselves recognize any opportunities in the courses they teach. One teacher responded, "There are few topics where issues can be easily brought up. Part of that is due to my lack of knowledge on these topics and the relationship to science."

In contrast, about half of respondents indicated that they recognized numerous opportunities to incorporate anti-oppressive lessons in the courses they teach. One responded to the prompt, "All classes. Whenever we talk about current issues and advancements or scientific discovery, current or historic". Another said, "I feel any topic could be used to discuss issues of oppression." Several teachers indicated specific points in their respective curricula which could connect to anti-oppressive lessons. The most common theme was representation. Participants suggested that any curriculum outcomes related to the history of science and notable scientists provide the opportunity to highlight the work of marginalized scientists. Some participants also expanded on this to suggest

that these outcomes could initiate more overt discussions of marginalization and oppression. One individual captured the sentiments echoed by many others in the statement, “Any unit could provide any number of opportunities to highlight not just token representation of scientists from marginalized groups, but also a critical look on how marginalization restricts participation from these groups.”

Numerous teachers noted that curriculum outcomes related to ecology provide opportunities to discuss the oppression of Indigenous communities and to highlight multiple epistemologies, such as Indigenous ways of knowing. Specifically, they mentioned the ecology units of Science 1206, Science 2202, and Science 7, as well as Environmental Science 3205, and the water systems unit of Science 8. One teacher noted that outcomes related to ecology and to climate provide opportunities to discuss the differential impacts of climate change on marginalized groups.

Multiple participants recommended that the reproduction unit of Science 9 and the reproduction and genetics units of Biology 3201 each provide opportunities for anti-oppressive lessons. However, few teachers elaborated on this. Those who did elaborate proposed that these units could accommodate lessons which cover reproductive justice as well as lessons that distinguish between sex and gender and acknowledge queer and intersex identities.

Interviews

Interview participants were asked to describe their understanding of oppression and of anti-oppressive teaching in relation to science. All interview participants indicated a strong sense of oppression and expressed that they see it as both a historical and an

ongoing issue in science. One interview participant, Jordan, explained that science has historically been used as a tool of oppression and colonization and that throughout history, groups with power have used it in their efforts to gain further control over different regions and peoples. All interview participants noted how marginalized groups have historically been denied access to science education and career opportunities. They discussed how those barriers have contributed to a harmful and inaccurate account where the most notable scientific advancements are almost always credited to white men. Participants emphasized the need to counter this narrative within their science classes. Jordan explained that without a conscious effort, teachers may, in fact, reinforce oppression in science;

> I think that is the easiest thing to do because it's already built into the system. If teachers don't have the consciousness that there is a problem (and often we don't because we haven't been taught that) and …the curriculum and the resources available reinforce that narrative, they're going to be reinforcing it …even if they don't want to.

4.1.3 Summary of Teachers' Views on Anti-Oppressive Science Teaching

Of the three research questions explored in this study, the data on teachers' views about anti-oppressive science teaching was the most divergent. It demonstrated the least consistency between participants as well as the lowest level of agreement between quantitative and qualitative data sources. The quantitative data exposed contradictions in teachers' views on oppression in science. Many questionnaire respondents seemingly expressed simultaneous beliefs that science upholds inequity but also that science is

beneficial to and accessible to everyone. Questionnaire respondents also varied greatly in their perspective on opportunities to incorporate anti-oppressive science teaching within their classes. In contrast, the qualitative data, acquired primarily through interviews, suggested that participants more readily acknowledged oppression in science. The qualitative data also conveyed a more consistently positive view of anti-oppressive teaching among interview participants. The findings suggest complexities in teachers' views of anti-oppressive science teaching and this is explored later in the discussion chapter.

4.2 Teachers' Practices Related to Anti-oppressive Teaching

4.2.1 Quantitative Findings

The questionnaire asked respondents to indicate how frequently they address various topics in their science lessons. The provided scale ranged from 1(never) to 5 (multiple lessons per unit). The data are shown below in Table 4 and Figure 4. Based on teachers' self-reporting, the most frequently addressed topic was sexism with an average rating of 2.83 on the 5-point scale and 83.3% of respondents indicating they address the topic to some degree within their courses. Implementation of lessons addressing the other topics was low, however. 58.6% never implement any lessons which cover disability or ableism, 46.3% never cover queer issues and 43.9% never cover Indigenous issues, while 33.3% do not incorporate any lessons related to racism in their science classes.

Table 4

Teachers' Practices Related to Anti-oppressive Teaching; Frequency of Lessons

	Response Frequency (n) And Percentage (%)					Mean	SD
Topic	1 Never	2	3	4	5- Several per unit		
Disability/ Ableism	24 58.6	11 26.8	6 14.6	0. 0	0 0	1.56	0.66
Indigenous Issues	18 43.9	10 24.4	11 26.8	2 4.9	0 0	1.93	0.81
Racism	14 33.3	15 35.7	8 19.0	5 11.9	0 0	2.1	0.8
Sexism	7 16.7	8 19.0	14 33.3	11 26.2	2 4.8	2.83	0.93
Queer issues	19 46.3	14 34.1	6 14.6	1 2.4	1 2.4	1.8	0.75

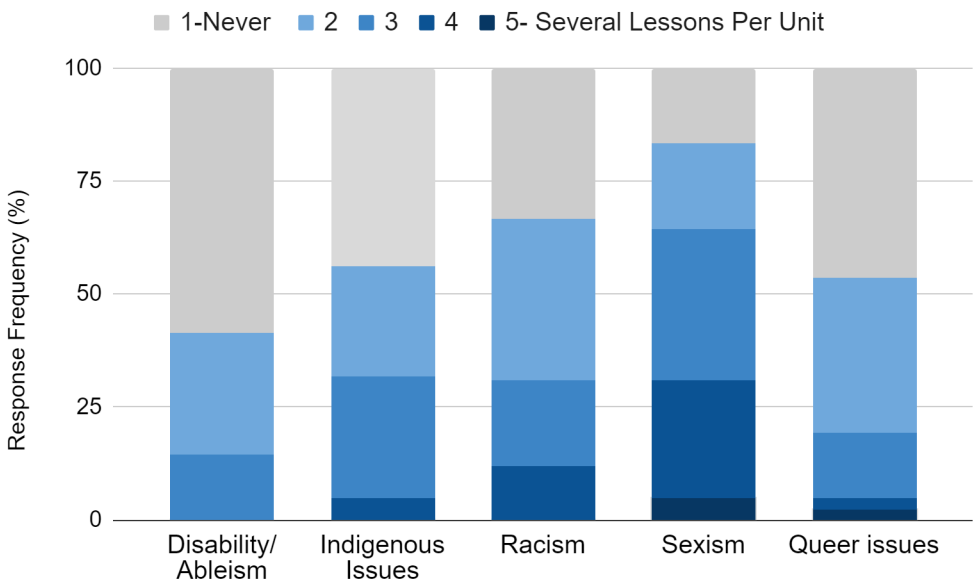

Figure 4

Teachers' Practices Related to Anti-oppressive Teaching; Frequency of Lessons

Teachers were also asked about the format of their anti-oppressive science lessons. This question was arranged with check boxes, and respondents could select each of the lesson formats they used. The data are shown below in Table 5 and Figure 5. Most respondents (61.9%) indicated that they address oppression through the inclusion of resources that celebrate diversity in science and several indicated that they address oppression through informal class discussions (26.2%). 4.8% of teachers use presentations or partnerships with community groups. Only 9.5% of respondents (4 teachers) indicated that they utilize lessons designed intentionally to confront oppression in science. Many participants (33.3%) did not respond to this section or indicated that they "rarely address" these issues in their science classes which agreed with the data on

the frequency of lesson implementation, as seen in Table 4.

Table 5

Teachers' Practices Related to Anti-oppressive Teaching; Lesson Formats

Lesson Format	Response Frequency (n)	Response Percentage (%)
Did not respond or indicate "Rarely address"	14	33.3
Inclusion of resources that celebrate diversity in science	26	61.9
Informal class discussions about inequality/ oppression in science	11	26.2
Presentations and partnerships with community groups	2	4.8
Lessons designed intentionally to confront oppression in science	4	9.5

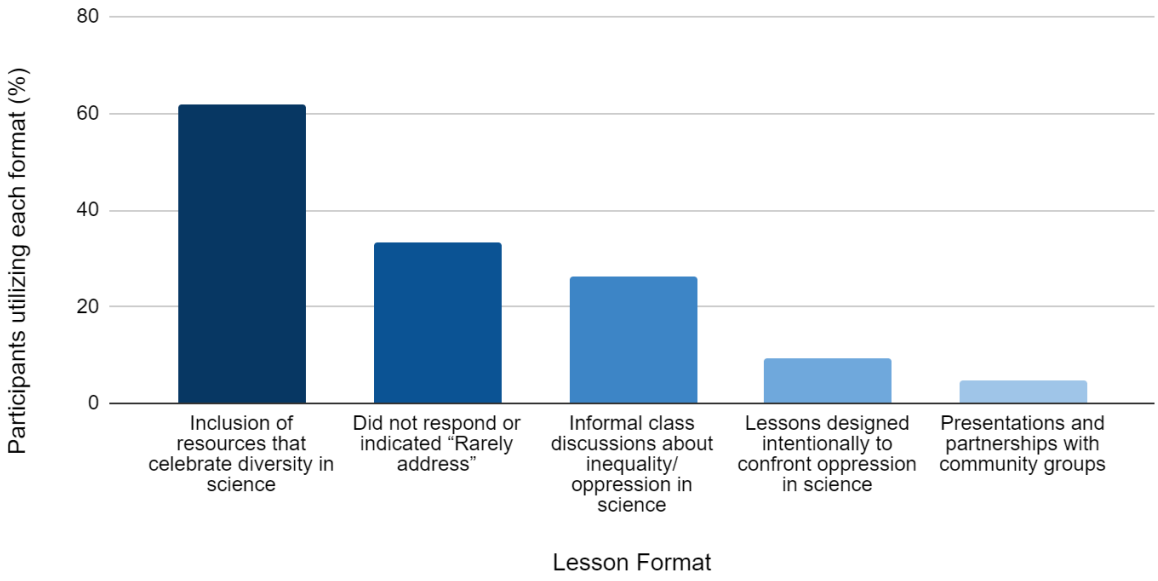

Figure 5

Teachers' Practices Related to Anti-oppressive Teaching; Lesson Formats

4.2.2 Qualitative Findings

Interview transcripts were reviewed and analyzed through the lens of Kumishiro's approaches to anti-oppressive teaching (2000). Kumishiro provides four broad strategies: (1) Education for the other, (2) education about the other, (3) education that is critical, and (4) education that changes. Multiple specific techniques indicated in the literature were used to expand on these four broad approaches as per Table 1 in Chapter 2. Upon analyzing the interview data, it is apparent that the participants of this study used several anti-oppressive teaching techniques within their classes.

Education for the Other

When sharing the practices they employ in their science classes, interview participants predominantly focused on those which would fit within the umbrella of

“Education for the Other”. Several participants discussed how they create inclusive spaces through the use of classroom posters and decor, by establishing culturally responsive classroom routines and expectations, and by maintaining flexibility in their teaching. Specific examples include considering cultural events and holidays not typically recognizied in the school calendar in the scheduling of tests or due dates; encorporating language aids and visuals to support English language learners; offering students time and alternate spaces for prayer or rest as needed; and differentiating and modifying instruction and assessment practices to suit student needs as well as cultural or religious practices such as alternatives to pig specimens for dissections. Teachers also emphasized efforts to develop relationships with students that make them feel welcome, safe, and valued. Participants noted that by engaging with students outside of the curriculum, either through extracurricular clubs and activities or through informal classroom discussions around students' personal interests, they could build relationships of trust and mutual respect.

One interview participant, Alex, emphasized modelling as crucial in establishing classroom culture. They explained that students often look to the teacher to see what is valued, and when teachers prioritize addressing certain behaviours over others, it communicates to students what is important. They noted that if a teacher seems to express more concern over things like punctuality or cell phone use than they do in addressing microaggressions or bullying in the classroom, it can send a harmful message. They suggested this would leave marginalized students feeling unsupported, and other students would miss the opportunity to learn valuable lessons about inclusion and equity.

> I think in interactions with students, the things that you take seriously in class and the things you don't take as seriously communicate what's important. So somebody goes to the bathroom every day and that might be a serious thing for some teachers and it's not a big deal. But then anything that's bullying, criticizing somebody's body or culture…. When you take those things seriously hopefully, you know, students, see that like that's past the line and they can understand.

Alex also noted the benefits of extracurricular student groups such as GSAs (Gender and Sexuality Alliances) or mental health clubs. They communicated that they support those groups as a teacher sponsor because they feel it is helpful "certainly in getting to know students more and trying to make sure that students feel that they like have a place to belong".

Another participant, Maggie, expressed an issue with the traditional classroom layouts. "The individual desks facing the front of the classroom. I see too much of that. Very traditionally, structured, not inclusive, not comfortable." They suggested reconfiguring the physical classroom design to employ alternative seating arrangements that are more flexible and comfortable and that facilitate more communication and collaboration between students. Several participants specifically noted the use of posters and decor in their classrooms. Jordan said they prioritize building "a safe environment in the classroom" and do that by allowing time and opportunities in their class schedule for students to "mingle and get to know each other." Jordan claims "I always encourage them to really get to know each other and not discriminate based on whatever preconceptions

they had". They discussed the importance of ensuring students feel welcome by both their peers and their teacher.

Drew emphasized accessibility and the need to ensure that class activities and laboratory investigations, in particular, are designed in a way that is mindful of students' needs, including students with disabilities. They spoke in particular about adapting a science lab for one of their students who is visually impaired. They needed to be conscious in their activity design to remove or reduce barriers to that student's engagement.

> I've got a student in one of my…classes who is visually impaired. And so trying to make the science accessible for her. Luckily she does have some vision. So she is able to see some of the things that we're doing, but it's got to be very close to her face. So when I'm designing a lab I need to be thinking about that. How to make sure that she is able to still see some of the things that we were doing and still in a way that's safe. We did a lab on solutions and separation and I just had to be thoughtful about the materials I chose to use and the quantities and then she was able to get out of that what everyone else was. That's important because labs are very much hands-on and being able to see what's going on.

Representation was by far the most frequently discussed approach to anti-oppressive teaching throughout all interviews in this research study. Each participant noted ways in which representation can be used "for the other" in ensuring marginalized students see themselves in the curriculum and see a place for themselves in science. Jordan explained that their classroom is becoming increasingly diverse, and "when you

consciously put that [representation of diverse scientists] into your lessons and your curriculum and your discussions in the classroom, it allows all of those diverse ethnicities in your classroom to feel seen and feel represented."

Participants suggested they approach representation both as a passive message communicated through classroom resources as well as an overt practice. Maggie spoke about using classroom posters or showing videos that depict diverse scientists. They spoke about the need to "normalize" that people of "different backgrounds, ethnicities, genders, etc. can contribute to work in various fields". Similarly, Jaime said they "try to inject people of all races, all cultures into the learning" and highlight "the well-known female scientists of history." They said they do this in hopes of providing "someone to inspire people in the classroom."

Education About the Other

The teacher practices noted above regarding representation can also be conceptualized under Kumishiro's "educating about the other" as all students in the classroom learn about diverse scientists and the contributions of various cultures to science and technology. Another practice that fits under both "for" and "about" the other is the inclusion of multiple epistemologies within science lessons. Two interview participants explained that they incorporate lessons that focus on traditional ecological knowledge or Indigenous science into their classes. Jordan discussed a lesson they use within the ecology units of Science 1206 and Science 2200: "I do this lesson on ecological justice and traditional knowledge and show a documentary about it. We talked about the ways in which traditional ecological knowledge has shaped science." Alex also

mentioned including discussions of Indigenous science within ecology lessons but did not detail the lesson on design. Maggie explained that they sometimes find it difficult to marry indigenous ways of knowing and school science but that they see value in it.

> Because of their [indigenous peoples] unique ways of knowing science compared to the Western ways of knowing science. We have such a focus on our Western scientific views that it is sometimes contradictory to teach…It can be difficult to incorporate multiple view points in science in the one classroom. But that is something that we need to practice. because there are more than one way of knowing.

Education that is Critical

In the previous sections, teachers' practices of incorporating representation in passive ways were noted. In addition to this, some interview participants described using representation in a way that is explicit and critical, engaging their students directly in inquiry around respresentation. Alex and Jordan both explained how they engage their classes in overt discussions to challenge the lack of representation in science curriculum and resources. Alex specifically discussed teaching the Science 9 space unit and how they engage with their class in inquiring why all of the notable scientists in their textbook or in many resources are white men. They use that opportunity to question the lack of representation in science and as a jumping-off point for discussions of oppression. Maggie highlighted a resource they use which contains the stories of women scientists.

> I actually printed out a couple stories from that book and I handed them around the classroom. We read the story as a class and had a discussion [about] what that

woman had gone through. What her life experiences were and relate what she discovered or her contributions to science to what we are currently teaching.

Maggie explained that they use this lesson to engage students in a discussion of how factors such as hiring bias and pay inequity contribute to the underrepresentation of women in science workplaces.

Alex noted many examples of how they engage their classes in lessons that explicitly address bias in science. They noted teaching about racial bias and abuse in medical research, specifically referencing the Tuskegee Syphilis trials. They also discussed a lesson in which they explored research with their classes that illustrates bias against women in academia.

> I talk to my classes about a particular research study that looked at how much more boys tend to speak up in science spaces and how even when girls speak an even amount it is perceived as being more. Like they are perceived as taking up more space when it's not the case or even the opposite. And so we talk about that bias and how that can affect what voices get heard or like valued in science and they always find that interesting to see those examples.

Participants also discussed lessons that focus on specific socioscientific issues. Jaime described how they engage their classes in lessons focused on how the biomagnification of pollutants in marine ecosystems disproportionately impacts Indigenous communities.

> When speaking about bioaccumulation and biomagnification in environments and how a lot of our accumulations occur in more remote indigenous populations. I

> usually do that as a science research study question for students and they explore that and we have group discussions.

Alex explained that in covering the concepts of sex, gender, and sexuality in their health classes, they take an approach that incorporates scientific understanding and social awareness:

> Certainly in health like that comes up and we talk about like gender and sexuality and identity and all of that. So I make an effort to use the most appropriate modern and scientific language for a situation. I try to avoid teaching those concepts from a heteronormative lens and when we discuss sexual health and sex education that it's inclusive. If we're covering an idea like consent, then I'll use some examples with same sex partners or use neutral language and try to, you know, normalize that. If I'm choosing videos or resources I'll try to make sure they include different perspectives.

Education that Changes

Many of the lessons described by the participants of this study centered on engaging students in class discussions. Teaching strategies such as this which center students and value the knowledge they bring to the classroom and the understandings they construct together are anti-oppressive. Jordan claimed, "I think it's all about discussions, you don't have to do a whole bunch of things to be able to plant that seed". Alex talked about the importance of providing opportunities for different students' voices and perspectives to be heard, "it's important that those voices, different students voices are heard too and that we try to bring out those voices a little more in our teaching".

Some participants also noted examples where they engaged students in action projects or lessons that position students to think of solutions to socioscientific issues. Jordan explained:

> I think it is our job to provide all of the facts and provide light to the things that they do not get to see. So that they can be like, 'Oh, Right. So this is a problem. How am I going to contribute to fix it?

Similarly, Jaime said they "try to inspire students to solve real-world problems to improve people's lives" but did not provide specific examples of lessons.

4.2.3 Summary of Teachers' Practices Related to Anti-oppressive Teaching

Compared to the findings related to teachers' views on anti-oppressive science teaching, the data related to teachers' practices exhibited a much higher degree of consistency among participants and between data types. Quantitative data revealed sexism as the issue which teachers feel most confident in and address most frequently in their science classes. Engagement with other topics was much lower. The data also demonstrated a clear preference for approaches that promoted inclusion and representation over lessons that explicitly addressed oppression. These same trends were evident in the qualitative data. While the qualitative data largely agreed with the quantitative data in this respect, it did provide additional context such as more detailed examples of teacher practices.

4.3 Factors that Influence Teachers' Implementation of Anti-oppressive Teaching

4.3.1 Quantitative Findings

The final piece of the questionnaire which yielded quantitative data was a series of questions focused on the factors that influence teachers' use (or lack) of anti-oppressive science lessons. This data is summarized in Table 6 and Figure 6 below. One question asked teachers directly which factors (if any) limit their implementation of anti-oppressive lessons. Respondents could select all potential responses that were relevant to them. There was a strong collective agreement that time constraints (78.6%) and a lack of training or preparation (73.8%) have a significant role. 38.1% also indicated a lack of confidence in discussing the topics was a limiting factor. Some teachers also indicated that these lessons did not align with what they perceived to be the priorities of school administration (7.1%), the school district (21.4%), or students' guardians (11.9%).

Two respondents (4.8%) added a separate response to this question to indicate that they are influenced by a lack of resources or prioritization within the curriculum. Three respondents (7.1%) also added a separate response to this question to indicate that they don't desire to include these topics because they do not feel it is relevant to science.

Table 6

Factors that Influence Teacher's Implementation of Anti-oppressive Teaching

Influence / Limitation	Response Frequency (n)	Response Percentage (%)
Confidence in discussing sensitive topics	16	38.1
Time constraints	33	78.6
Lack of training or preparedness	31	73.8
Perceived priorities of school administration	3	7.1
Perceived priorities of school district	9	21.4
Perceived priorities of guardians	5	11.9

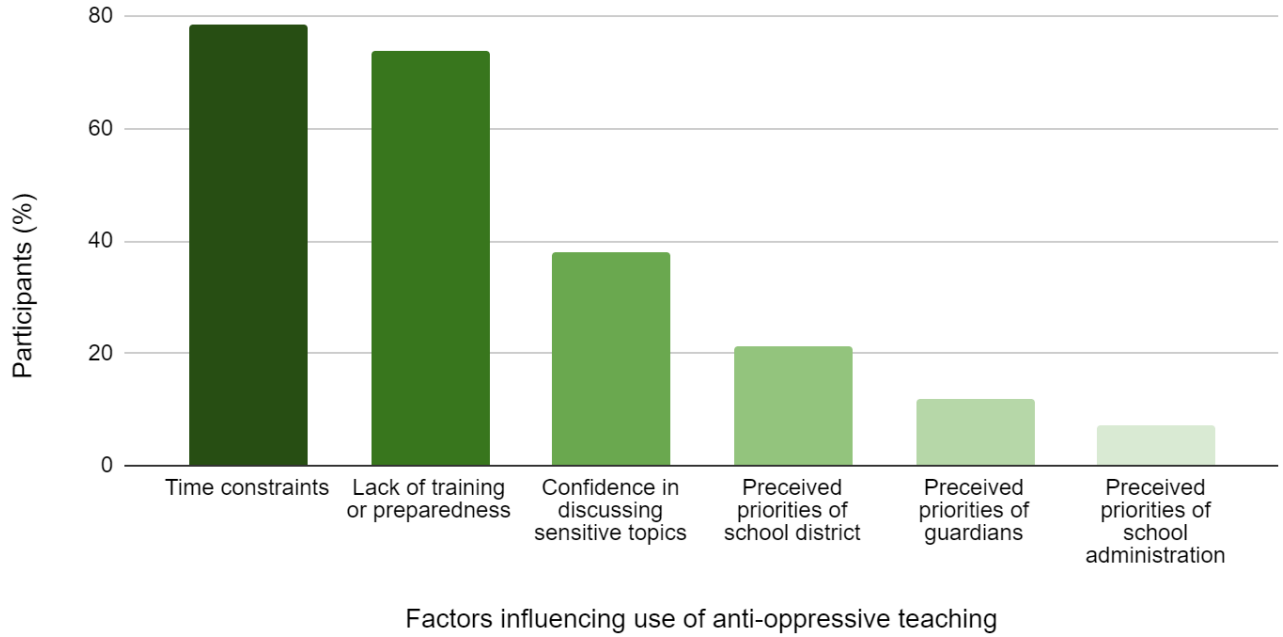

Figure 6

Factors that Influence Teacher's Implementation of Anti-oppressive Teaching

It was anticipated, based on the literature review, that teachers may lack confidence in approaching these concepts within their science classes. Therefore, within this section of the questionnaire, teachers were asked to rate their level of confidence in discussing each topic on a scale from 1 (not confident) to 5 (very confident). This data is shown in Table 7 and figure 7 below. It was apparent that teachers felt much more confident in discussions of sexism than with any other topic. The mean confidence for lessons around sexism in science was 3.5 on the 5-point scale. For all other topics, the mean rating was below 3.

Table 7

Teachers' Self-Reported Confidence in Covering Various Topics in Science Classes

	Response Frequency (n) And Percentage (%)						
Topic	1- Not confident	2	3	4	5- Very confident	Mean	SD
Disability/ Ableism	15 35.7	13 31.0	8 19.0	6 14.3	0 0	2.12	0.87
Indigenous Issues	14 33.3	14 33.3	5 11.9	9 21.4	0 0	2.21	0.95
Racism	8 19.0	12 28.6	13 31.0	7 16.6	2 4.8	2.60	0.95
Sexism	3 7.1	7 16.7	7 16.7	16 38.1	9 21.4	3.50	1.02
Queer issues	16 38.1	9 21.4	8 19.0	4 9.5	5 11.9	2.36	1.19

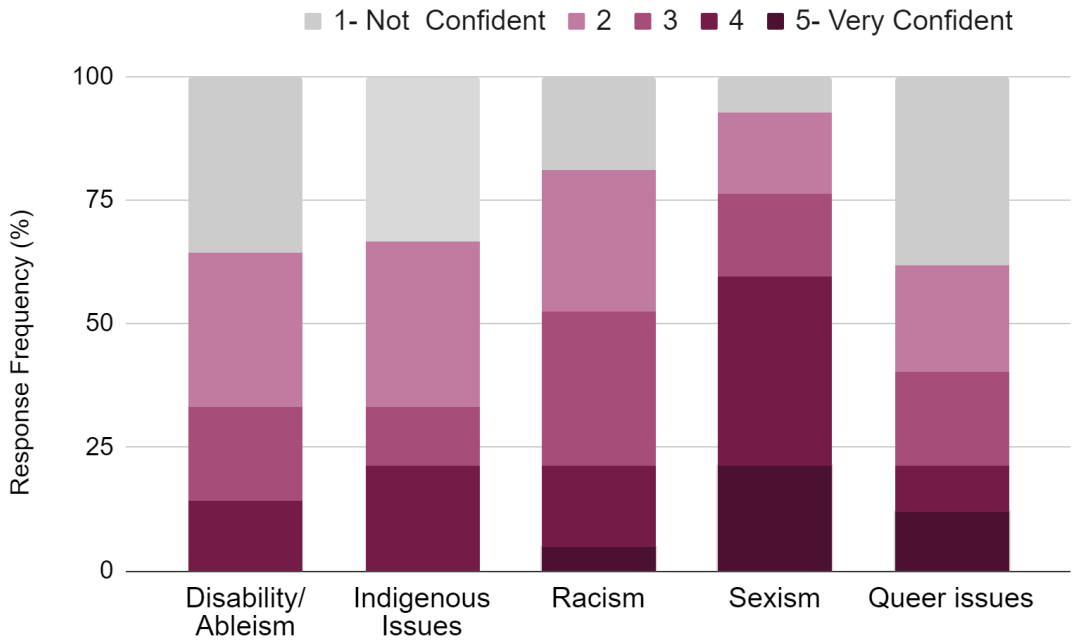

Figure 7

Teachers Self-Reported Confidence in Covering Various Topics in Science Classes

4.3.2 Qualitative Findings

At the end of the questionnaire, participants were asked if they'd like to share any other thoughts that were not invited directly by the previous questions. Multiple teachers indicated that they would like to do more in terms of anti-oppressive science teaching, and they would like to see the curriculum and resources updated to include it. They also indicated that they would like "further education or PD [professional development]." One teacher wrote:

> Although it is true that the curriculum is jam-packed and therefore we, as teachers, often feel that time is a huge constraint, I believe that if we truly want

> to engage in these critically important conversations, we will make them a priority in the classroom and make time for them. This, of course, can only go so far unless you have support from admin, colleagues and the district so that it becomes part of the school culture.

Interview participants cited their own personal experiences as being a strong motivating factor in their desire to employ anti-oppressive teaching. Maggie explained that their lived experience as a woman in science has exposed many challenges and those experiences encourage them to address such issues in their science classes. Jordan discussed how the discrimination they have experienced as a woman and as a person of an ethnic minority motivates them:

> I have experienced discrimination myself… that has made me aware that there's always been an issue. And I think that I actively seek… to integrate a lot of anti-oppressive education…wherever I can because I know how important it is to change that narrative. Because I know that my students from diverse backgrounds, they're going through that. So if I can in some way alleviate the experience that they're going through. Then…it's my responsibility to do so.

Jordan also suggested that the diversity of students in their classroom influences their teaching practices: “I think when my classes are more diverse, my teaching in response becomes more diverse as well and more inclusive”.

Several participants cited witnessing the experiences of others around them as motivating their anti-oppressive teaching. Maggie, Jaime, and Alex each described seeing friends or loved ones face discrimination and connected this to their desire to engage in

anti-oppressive work. Jaime also mentioned how “paying attention to the collective dialogue” has promoted their anti-oppressive teaching. They explained that media and discussions on online platforms have raised their awareness “that it’s important that even if it doesn’t affect me directly or my students directly, that is an important conversation and important focus to allow space for.”

All participants discussed time as a limiting factor in finding, reviewing, and implementing new anti-oppressive lessons and resources. Maggie and Jaime both described the current curriculum as “overloaded,” and several participants described feeling a “pressure” to “get through it.” Maggie stated, “There are definitely these invisible forces to keep with the status quo to continue the same path to provide the same type of teaching that has been given for many many years before.” All interview participants repeatedly indicated that they would like to see changes to their respective science curriculum that would “build in” more outcomes and opportunities to implement anti-oppressive lessons. Jaime explained that if addressing topics of oppression in science were “mandated” it would allow teachers to “focus on it more purposefully”. Jordan also stated that they would like to see outcomes on oppression in science incorporated into the curriculum and would like to have the feeling that “the school district and administration mandates and supports that.” Jaime stated, “I don't feel there's been an acknowledgment that science and science research has been used to oppress people” and they called for “acknowledgement” and “measurable action.”

When asked what support they would need to implement more anti-oppressive teaching, all interview participants indicated that they would like more professional

development opportunities and to be provided with more relevant teaching resources. Interview participants indicated that they did not receive any specific training on anti-oppressive teaching within their initial teacher education programs and only two of the five interview participants had been offered professional development related to anti-oppressive teaching during their careers. Jaime attended PD on culturally responsive teaching and Alex attended PD focused on gender and sexual diversity inclusion. Neither PD session included any content specific to science and both participants expressed that they felt the PD could have been more useful if it had been more "authentic" and more practical. Jordan said they would like to see, "way more professional development that is practical, not general. It's how do you deal with it in the classroom. I think that's the missing part and that's what most teachers shy away from because they don't feel comfortable with that." Drew said, "I'd really like to be able to do more of it [anti-oppressive teaching], I just don't know how to approach it". They explained, like others, that they would appreciate more professional development but also more relevant resources and activities that they can use in their classroom.

Alex and Jaime spoke repeatedly about the need for resources to be "authentic", meaning developed by members of the relevant marginalized communities. Alex specifically stated that they would like to be able to bring the voices of marginalized folks into their classroom more either through guest speakers or via books or videos of people sharing their experiences. Jaime explained that providing teachers with approved lessons and/or resources developed by "legitimate sources" would encourage more implementation of anti-oppressive teaching because it would help teachers feel more

confident in taking on issues that are sometimes seen as controversial. They claimed it would “add a layer of protection” and help them to avoid making mistakes.

Class size was noted as an important factor by one participant. Maggie stressed that they felt that smaller class sizes would support the implementation of anti-oppressive teaching and promote engagement. While a connection between class size and anti-oppressive teaching was not suggested by any other participants in this study, teachers within the province have long raised the issue of class size as an important concern (Government of Newfoundland and Labrador, 2022; NLTA, 2019).

4.3.3 Summary of Factors that Influence Teachers’ Implementation of Anti-oppressive Teaching

There was substantial agreement between quantitative and qualitative data related to factors that influence teachers' implementation of anti-oppressive teaching. This is true in regard to the factors which teachers claim limit their use of such practices as well as the factors which they cite as promoting their engagement with anti-oppressive teaching. Here the quantitative data was able to provide insight into the most relevant factors which emerged as time constraints and lack of training and preparation. The quantitative data was able to enrich this understanding by providing additional context through teachers' detailed explanations. The quantitative data also allowed for the emergence of additional relevant factors. The open ended nature of the interview questions provided the opportunity for responses which were not included in the questionnaire response options.

For example, teachers emphasis on their own personal experiences with marginalization as a motivator as well as teachers desire for authentic resources.

Chapter 5: Discussion

The objective of this research study was to investigate intermediate and secondary science teachers' views and practices regarding anti-oppressive science teaching. Three research questions guided this study: (1) What are science teachers' views of oppression and anti-oppressive teaching in science? (2) To what extent and in what ways are teachers employing anti-oppressive science teaching? (3) What factors promote or limit teachers' implementation of anti-oppressive science teaching? In this section, the study's results will be discussed in the context of the existing literature and its implications for science education.

5.1 Teachers' Views of Oppression and Anti-oppressive Teaching in Science

Questionnaire data showed widely varying perspectives on the topic of oppression in science. Interestingly, responses to some questions suggest that participants hold simultaneous, contradictory views. They mostly concurred that science is accessible to and benefits all equally. At the same time, they mostly agreed that science has historically perpetuated and continues to perpetuate forms of oppression. This apparent contradiction may at first seem perplexing. However, in light of the long-standing discourse regarding the fundamental nature and philosophy of science, as well as its place in science education, such mixed views are not entirely unexpected (Chike, 2021; Kötter &

Hammann, 2017; Rudolph, 2000). It does appear that NLESD's secondary science curriculum is trending toward a greater focus on such topics. Over the past five years, many of the high school science curricula have been revised and each updated curriculum included a notable focus on the nature of science and its relationship with technology, society, and the environment (STSE). Still, there is some division regarding the incorporation of socio scientific issues within school science. Three questionnaire respondents stated opinions that social issues lack relevance to science and that those discussions belong only in other classes, such as social studies. Stewart (2010) describes how the common perception of science as value-neutral and objective contributes to this resistance. Similarly, scientist and activist Jon Beckwith recounts his and others' experiences working to bridge the gap between science and society (2002). Beckwith claims, “Those of us who publicly raised concerns about the social consequences of science were mistrusted by other scientists. Scientist-activists were dismissed with suggestions that their research had gone downhill (2002, p.158)”. Beckwith goes on to outline examples of this phenomenon: Prominent Canadian geneticist David Suzuki received much criticism for his work raising issues of socio-scientific concern in the media, and Benno Müller-Hill encountered hostility following the publication of his work shining light on the extent of the German scientific community's participation in Nazi eugenics and human experimentation (2002).

Even when teachers recognize the benefits of exploring science topics in the context of society and the environment, coverage tends to focus on technology, environmental impacts, or general ethical questions that don't directly question power or

privilege (Galloway et al., 2019; Sheth, 2019). There is resistance to lessons which overtly address oppression or interrogate power dynamics. Aikenhead (2000) claims that this “suggests that school science must somehow be serving the interests of dominant stakeholders who enjoy social, economic and political power in society” (p. 257).

Compared to questionnaire respondents, interview participants demonstrated a much more consistent view of oppression in science. They agreed that it is not only a historical issue but also an ongoing one and were able to provide examples that illustrate this. The difference in the questionnaire and interview participants' viewpoints might suggest that teachers who opted to participate in the interview were those who have more interest in and, perhaps, a deeper understanding of oppression in science. It was not the goal of this study to consider correlations between participant demographics and views of oppression and anti-oppressive teaching. However, it is suggested that this may be an interesting question for future examination.

These results suggest that one important step in promoting anti-oppressive education would be building awareness and consensus among science teachers around oppression in science. This is supported by the literature, including Horgan & Horowitz (2022). This is explored further with other factors that promote teachers' implementation of anti-oppressive teaching in section 3 of this discussion.

5.2 Teachers Practices Related to Anti-Oppressive Science Teaching

The results of this study indicate that the frequency with which teachers address oppression in their science classes varies greatly both across topics as well as between

teachers. However, across all data, it was clear there is much room for improvement. It was also evident that when efforts were made, they primarily focused on representation and celebrating diversity and largely neglected to name or confront oppression outright. This is noteworthy as it has been shown that teacher practices are central in the work of anti-oppressive science teaching. An extensive synthesis of research focused on college STEM participation recently showed pedagogical practices to be among the most influential factors in promoting participation among racially minoritized students (Bottia et al., 2021).

5.2.1 Lesson Topics

According to both questionnaire and interview data, of the topics listed, sexism is the most frequently covered topic. It is also the topic respondents expressed being most comfortable addressing. It is possible this is related to the demographic data of the study as many more participants self-identified as women compared to any other marginalized group. However, as previously noted, an investigation of this connection is beyond the scope of the current study. It may also be the case that issues of gender disparity in science have received more attention in the literature and within the local community. WISE NL was founded in 1988 as a volunteer, non-profit organization which aims to support and promote women in STEM within the province (Women in Science and Engineering Newfoundland and Labrador, n.d). Many of the organization's initiatives involve collaboration with local intermediate and secondary school science classes as they promote mentorship opportunities, workshops, and more. These efforts have

undoubtedly influenced science educators within the province, spreading awareness of gender disparities in science and encouraging action. This was evident through the interview process as several participants spoke of the organization. Still, over 16% of questionnaire respondents reported never addressing issues of sexism in their science classes.

Teachers indicated that their engagement with other topics, including disability/ableism, Queer issues, Indigenous issues, and racism, is considerably lower. Notably, several participants reported that they never directly addressed these topics in their science classes. Teachers also reported feeling less confident in their knowledge of these issues. These findings align with a growing body of research that highlights the need for greater attention to anti-oppressive education in science at all levels (Graves et al., 2022; Spang & Bang, 2015; Stewart, 2010; Upadhyay et al., 2020).

5.2.2 Lesson Strategies

In terms of Kumishiro's (2000) four approaches to anti-oppressive education, teachers were much more likely to employ practices which fit with "Education For the Other" and "Education About the Other" but rarely those which could be viewed as "Education that is Critical" or "Education that Changes."

Educating For The Other

All interview participants and many questionnaire respondents discussed fostering inclusive classroom environments and developing relationships with students, approaches consistent with Kumishiro's "Education for the Other." Research supports this as a

necessary foundation for a positive and equitable learning experience (Chowning et al., 2022; Estrada et al., 2011; NSTA, 2019; Wong & Saunders, 2020). Such practices are valuable to all students but are particularly imperative for students of marginalized identities who often experience a reduced sense of belonging within science spaces (Johnson, 2012; Rainey et al., 2018; Strayhorn, 2012).

Participants also explained that they are conscious of ensuring lessons, labs, activities, and assessments are accessible to all students. Some outlined specific examples of ways they have adapted lessons to promote accessibility. The literature supports this as an important aspect of anti-oppressive teaching (Abu-Boateng, 2019; Bell, 2019).

There are other elements of "Education for the Other" that seem to be under-employed among the study's participants. Namely, only one interview participant described using strategies to directly disrupt biases, stereotypes, and microaggressions in their science classes. Examining biases and microaggressions can be uncomfortable work (Chan et al., 2020). However, it is vital to support marginalized students, particularly within a field in which they are more likely to experience such concerns (NSTA, 2019; Saunders & Wong, 2020).

Additionally, the literature emphasizes the importance of connections between school, community, and family, particularly for marginalized students in science (Chowning et al., 2022; Morrison & Bell, 2018). Milne studied the relationships between families and schools in Southern Ontario (2016). Their findings supported the importance of these connections but also acknowledged how historical and ongoing oppression constitute barriers to them.

> Student success is facilitated by strong bonds between families and schools, including a shared sense of purpose and mutual trust. However, for Indigenous peoples, these relationships are often broken, undermined by the legacy of residential schooling and assimilative educational practices
> (Milne, 2016, p.1).

Further research has found that children who experience “cultural discontinuity between home and school may perceive themselves as poor learners and may develop a negative self-concept” (Souto-Manning & Hanson Mitchell, 2010, p. 270). The Truth and Reconciliation Committee called on the government to prioritize enabling parents to participate fully in the education of their children (2012). Sutherland and Swayze also suggest that when teachers have a close connection to the community, they can draw on that relationship to enrich learning experiences (2012). Connecting community and curriculum has also been shown to contextualise outcomes and help students build connections between their learning and their own lives (Hauser et al., 2009; Nelson-Barber & Estrin, 2015). The Elementary Teachers' Federation of Ontario published a brief guide to addressing anti-Asian racism in schools (Chan et al., 2020). Within it, they assert that anti-oppressive administrators and educators strive to prioritize authentic partnerships with parents and families (Chan et al., 2020). They go on to outline steps for this, including addressing language and cultural barriers to foster greater parent engagement. They suggest surveying families to find out their preferred means of communication and providing translations, where possible, for school newsletters and emails. They also discuss the need to remove barriers to ensure that school councils are

reflective of the diversity of the broader school population. These sources illuminate the need for schools and teachers to work to build trust and positive relationships with families and communities as well as the benefits of bridging community and curriculum. Unfortunately, the results of this study indicate that efforts in this regard are minimal. Partnerships with community groups were rated by questionnaire respondents as the second to least frequently used strategy. Furthermore, the topic was not suggested by any of the interview participants.

Education About the Other

As previously mentioned, many practices can be aligned under the umbrella of "Education for the Other" as well as “Education About the Other.” One notable example is representation. Both the questionnaire and interview participants strongly emphasized the importance of representation within their science classes. In fact, throughout both data collection modes, it was the most frequently discussed strategy by far. Teachers cited the use of classroom posters, videos, and stories about diverse scientists to normalize and promote the participation of individuals from various backgrounds in the fields of science. Providing students with opportunities to see themselves in the course content has been shown to enhance their sense of belonging and motivation (Archer et al., 2015; Bakshi, 2020; Long et al., 2022; NSTA, 2019). Furthermore, centering the histories and voices of marginalized communities and selecting resources that emphasize their contributions also serves to counter bias and prejudice among the dominant community (Morrison et al., 2017; NSTA, 2019; Wong & Saunders, 2020). In these ways, representation is an important component of anti-oppressive science teaching which

benefits all students.

Also straddling the categories of education “for” and “about” the Other is the practice of honouring multiple, diverse epistemologies. There is growing recognition and criticism of the way in which school science promotes an almost exclusively Eurocentric, white, Western science paradigm. Le and Matias explore this concept and claim that “the resounding belief that science is universal and objective hides the reality that whiteness has shaped the scientific paradigm (2019, p. 23)”. They go on to explain that “knowing science in the absence of other ways of knowing only furthers whiteness and White supremacy through power and control of science knowledge. As a result, our students of Color are victims of deculturization, and their own worldviews are invalidated” (Le & Matias, 2019).

Several questionnaire and interview participants noted specific curriculum areas within their science courses where Indigenous Ways of Knowing could be included. Some outlined examples of lessons or resources they use. This is promising, though it should be noted that the literature cautions that simply incorporating Indigenous knowledge without wider efforts to truly honour Indigenous perspectives and practices risks the appropriation of Indigenous knowledge into the Western science framework (Hauser et al., 2009). Le Grange (2004) and Cajete (1999) found that often, when Indigenous knowledge is addressed in science curriculum, it is presented as separate and opposed to Western science. Le Grange (2004) and others advocate for the development of a curriculum that sees these perspectives complement one another and recommend that

science teachers build connections between Indigenous Ways of Knowing, local and cultural knowledge, as well as Western science (Bell, 2019; Spang & Bang, 2015).

The First Nations Education Steering Committee recommends that only authentic, Indigenous-created resources be employed when engaging with Indigenous issues (2012). They note that, though often well-intended, many resources used in the past contain inaccuracies or misrepresent Indigenous worldviews and experiences (TFNESC, 2012). This was acknowledged by two interview participants who stressed the importance of access to authentic resources developed by or in collaboration with Indigenous communities. One specifically noted examples they had witnessed of non-Indigenous teachers utilizing resources and engaging in practices that may have been considered appropriative. Though this concept of "authentic" resources was referenced with respect to Indigenous resources, the same logic could be extrapolated to hold that any resources which focus on a marginalized demographic should be created by or in close consultation with said community. The adage "nothing about us without us," most notably promoted by the disability rights movement, could aptly apply here (Charlton, 1998).

Education That is Critical

Few questionnaire respondents indicated using strategies which fit with Kumishiro's concept of "Education that is Critical". This includes lessons which would expose the historical and ongoing injustices in science and promote what Freire calls "conscientization" (2005). Less than 30% engage in informal class discussions that are critical, and less than 10% conduct lessons specifically designed to confront oppression. This is unfortunate, though expected based on existing literature. Galloway et al. cite

several studies which found that teachers dedicate significantly more attention to honouring differences, celebrating diversity, and ensuring representation but comparatively little time to overtly address systems of oppression (2019). Le and Matias call this approach "safe multiculturalism" and problematize its popularity, particularly among white teachers (2019). In a 2019 study, Sheth found that even among teachers specifically engaged in strategies to support students of colour in science, they "were not prepared to question and disrupt dominant racial ideologies embedded in learned notions of science and science teaching" and instead engaged in colorblind ideologies (p. 55). Le and Matias explain how this approach reinforced oppression as "colorblindness hinders racial justice and allows whiteness to continue its dominance because underneath the notion that all should be treated fairly are White-normed historical social practices that preserve the system of White supremacy" (Le & Matias, 2019, p. 26).

While interview participants, like questionnaire respondents, did not focus on critical pedagogy, some did describe lessons in which they engage students in explicit and critical discussions about bias and oppression in science. Teachers specifically noted examples addressing racial bias, abuse in medical research, and gender inequity in academia. Participants explained that these topics were typically addressed via class discussions. Current research supports the use of dialogical processes and building a "culture of discourse" in lessons around social justice (Bakshi, 2020; Santos, 2009). Because of the sensitive and sometimes controversial nature of these topics, Morrison et al. highlight that it is imperative that teachers develop norms for respectful and effective classroom discussion (2017). Some interview participants specifically cited the need for

such groundwork both to ensure that discussions are productive and also to support marginalized students within their class.

The literature also promotes lessons and activities in which both teachers and students interrogate their own perceptions of science and scientists to address positionality, bias, and privilege (Morales-Doyle, 2017; Morrison & Bell, 2018; Snively & Williams, 2018). This might include activities like the “Draw a Scientist Test” or implicit bias tests (Finson, 2002). These practices were not discussed by the participants of this study.

Education That Changes

Finally, while not a priority evident from the questionnaire responses, some interview participants did describe lessons consistent with Kumishiro's "Education that Changes" (Kumishiro, 2000). This includes lessons which are student-centred, those that invite students to engage directly with socio-scientific issues, and action projects that empower students to make change.

Education that changes can begin with practices that subvert the traditional hegemony of the classroom. As such, lessons that center students and promote participatory culture and collaboration are essentially anti-oppressive and fit within the model of “education that changes” (Davis et al., 2015; Santos, 2009). Several interview participants described engaging in “active discussions” with their science classes. They spoke about valuing all students' experiences and voices and ensuring that all students felt heard. hooks promotes the importance of this, claiming, “any radical pedagogy must

insist that everyone's presence is acknowledged (2014, p. 8)". Hatcher et al. emphasize the importance of this for Indigenous learners in particular, explaining that in Western ideology, "knowledge is a noun, to be passed objectively from one person to another," but in many Indigenous languages, "knowledge is a verb, and the teacher and learner both play a constructive part in it" (2009, p. 146). Palmer further supports this approach for all students, stating that "good teaching is always and essentially communal" (Palmer, 2007, p.115)".

Evidence also suggests that it is important to engage in decolonizing the structure of how science lessons and classes are designed. The United Nations Declaration on the Rights of Indigenous People resolves that Indigenous peoples have a right to education in a manner appropriate to their cultural methods of teaching and learning (United Nations, 2007). One specific strategy toward this end would be decompartmentalizing the curriculum. In our current education system, subjects and even science disciplines are separated into different courses with discrete outcomes and broader connections are rarely appreciated. Seidel and Jardine describe this as the "fragmentation of the living fields of knowledge" (2014). Sutherland and Swayze suggest this does not align with many Indigenous cultures in which "learning and knowledge are traditionally integrated throughout disciplines" (2012). This approach was not noted in any questionnaire responses or interviews.

Another strategy that would honour Indigenous perspectives while also enhancing the science learning experience for all students is land-based and place-based education (Bell, 2019; Spang & Bang, 2015). Sutherland & Swayze (2012) advocate for science

classes to participate in direct experience in local, outdoor environments. The First Nations Education Steering Committee also emphasizes the importance of a connection to the land for Indigenous learners (2012). They claim that "connection with place, with the land, is the foundation of Indigenous knowledge" and making connections to place and land is "an integral part of bringing Indigenous perspectives into the classroom (TFNESC, 2012)".

Finally, anti-oppressive science teaching requires lessons to go beyond "conscientization" and engage in praxis. Chan et al. support this stating, "After establishing the historical and systemic basis for these inequalities, the next question is: What are you going to do about it? Social action is fundamental…and the goal should always be to create change (Chan et al., 2020, p.60)". Several resources highlight the importance of making science education accountable to community goals and providing students with opportunities to apply their knowledge to real-world problems and engage in relevant action projects (Bell, 2019; Morrison, 2017; Santos, 2009; Upadhyay et al., 2020). Zeildler and Nichols suggest that such approaches can inspire in students a sense of agency and social responsibility and empower them to make real-world change (2009). Smith et al. investigated the relationship between communal goals and Indigenous students' experiences in STEM (2014). They found that students experienced a strong sense of belonging, greater motivation, and better outcomes when they engaged with a communal goal or felt that they were "giving back" to their community. These approaches also align well with NLESD's goals of promoting collaboration and citizenship and, in this way, elevate science education for all students (NLDE, 2021).

No study participants spoke about land- or place-based science teaching, and just one interview participant specifically indicated the use of action projects within their science teaching. It should be noted, however, that it is possible teachers are incorporating land-based teaching and science action projects focused on topics such as environmental issues, while not recognizing this as anti-oppressive work. This would lead teachers to underreport their use of such strategies when asked explicitly about anti-oppressive teaching.

5.3 Factors that Influence Teachers' Implementation of Anti-oppressive Teaching

The factors participants reported as influencing their use of anti-oppressive teaching aligned closely with existing literature on the topic as well as literature focused more generally on progressive pedagogy.

5.3.1 Teacher Diversity Gap

Teachers cited experiencing or witnessing others experience oppression as motivating their desire to implement anti-oppressive teaching strategies. They also explained that increasing diversity within their classrooms further encourages their efforts. Newfoundland and Labrador has the least ethnically diverse population in Canada and is overwhelmingly white, Christian, English-speaking, people of European descent (Statistics Canada, 2017). Though diversity is increasing, the province remains very homogenous (Collins et al., 2017; Li & Grineva, 2016). While the provincial government does not collect specific demographic details on NLESD teachers, it would be reasonable to assume that there exists a comparable lack of diversity within this sub-population. In

fact, studies in other jurisdictions have raised concerns about a "teacher diversity gap", in which the marginalized identities of the student population tend to be significantly unrepresented in the composition of the associated teacher workforce (Abawi & Eizadirad, 2020; Hrabowski & Sanders, 2014). A 2015 study showed that in Ontario, racialized minorities represent 26% of the population but only 10% of secondary school teachers (Turner Consulting Group, 2015). In Toronto, that gap was larger, with racialized minorities representing 47% of the population but only 20% of secondary school teachers (Turner Consulting Group, 2015). A 2023 study showed a similar trend among physical and health educators across Canada (Sulz et al., 2023). Because marginalized identities are generally underrepresented in science degree programs, which are typically a prerequisite to teaching intermediate and secondary science in Newfoundland and Labrador, it might be expected that the diversity gap among science teachers in particular, could be even more pronounced. Due to the absence of recent data specific to Newfoundland and Labrador's teaching population and more specifically, its science teaching population, it is difficult to draw a meaningful conclusion. It is therefore suggested that further research in this area is warranted. Should such research demonstrate a significant diversity gap, it would certainly have implications for anti-oppressive teaching, and efforts to close that gap would support anti-oppressive science teaching goals.

Firstly, marginalized students would benefit directly from the experiences of shared identities, representation, and access to role models (Sulz et al., 2023). Research also supports the enhanced productivity of a diverse teacher workforce, as collaboration

among individuals with different backgrounds, experiences, and perspectives leads to innovation and improved problem-solving (Graves et al., 2022). Furthermore, as noted above, interview participants cited their own experiences with oppression as motivating them to engage in anti-oppressive teaching. Therefore, if the local science teacher population were more diverse and included more representation of marginalized individuals with lived experiences, they might be more inclined to practice anti-oppressive teaching. Janzen and Cranston (2016) support the need for diversification of the teaching workforce in Canada, and Turner (2015) states that it will not occur without a deliberate and comprehensive action plan. Abawi and Eizadirad respond to this by outlining several necessary steps, including enhanced data collection to improve transparency, the development of comprehensive diversity and inclusion policies based on consultation and collaboration with key stakeholders, and efforts to promote diversity in teacher training programs as well as hiring of diverse teachers within school districts (2020).

5.3.2 Preparation and Training

Across both questionnaire respondents and interview participants, most teachers noted a lack of training or preparedness as being a crucial factor in limiting their engagement with anti-oppressive teaching. Participants described a lack of focus on such topics within their initial teacher education as well as an absence of relevant professional development. The need for additional training in this area is well-supported in the literature (Horgan & Horowitz, 2022; Le & Matias, 2019; Schindel Dimick, 2016;

Stewart, 2010).

While they appear to be improving, the literature suggests that science teacher education programs tend to reinforce Eurocentric traditions and reflect the prejudices of the societies in which they operate (Burke, 2022; Valdez, 2022). More can be done within these programs to better prepare science teachers to take on anti-oppressive teaching. One specific challenge is that many teachers themselves may not have developed sociopolitical consciousness (Laughter & Adams, 2012). Horgan and Horowitz (2022) underscore the importance of fostering this consciousness within preservice science teacher education and claim that "teachers must explore their own identities and positions" (p. 909). Aveling (2012) and Burke (2022) explore possible approaches to promote consciousness within teacher education programs. In addition to promoting general consciousness, research also highlights the need for science teacher education to focus specifically on the history and philosophy of science, including the role of science in colonization and oppression (Stewart, 2010). If teachers are to engage their students in critical analysis of the role of science in society then it is first imperative that the teachers themselves have an awareness of the historic and ongoing oppression. Beyond that, they must have an awareness of how to bring those topics into the classroom and of teaching approaches and strategies that are appropriately sensitive as well as effective. Perhaps the most authentic way in which teacher education programs could prepare preservice science teachers to engage with anti-oppressive teaching is if the programs themselves employed such practices. This approach would not only promote anti-oppressive teaching through modelling but would also support preservice science teachers of marginalized

identities. At Memorial University of Newfoundland and Labrador, at least two teacher educators are leading the way on this. Azam and Goodnough (2018) engaged in self-study to explore several approaches to indigenize their science methods courses within the bachelor of education program. Though they used the terminology of "Two-eyed Seeing" and "Culturally Relevant Pedagogy," the guiding principles which emerged from their study correspond closely to the tenets of anti-oppressive teaching.

Comprehensive and ongoing professional development (PD) also has an important role in building and maintaining an anti-oppressive system of science education. Few participants in this study indicated having ever received any PD related to oppression or anti-oppressive teaching and none had ever received any which focused specifically on science teaching. A 2017 review exploring the characteristics of effective PD design identified seven key elements (Darling-Hammond et al., 2017). The first feature the review highlighted was that effective PD is content-focused. The study clarified that PD should be discipline-specific and content-based. This may be particularly relevant in the case of anti-oppressive teaching. As previously discussed, the widespread misconception of the neutrality of science often perpetuates a blind spot in acknowledging oppression in science. Several questionnaire respondents indicated that they do not recognize any connection between oppression and science teaching, and they feel such topics would be more suited to social studies classes. Others indicated they had never considered a connection before engaging with the questionnaire. It may, therefore, be expected that if these same teachers were to engage in a generic PD focused more generally on the concept of anti-oppressive teaching, they may not themselves identify

the relevant connections to science or to their specific course content. For this reason, it is suggested that although most anti-oppressive teaching practices are not unique to science, science teachers and their students would benefit most from PD that is centred directly on anti-oppressive teaching in the context of science.

The Darling-Hammond et al. (2017) study also indicates that effective PD incorporates active learning, collaboration, modelling of effective practice, coaching and expert support, opportunities for feedback and reflection, and is of sustained duration. Several of these priorities were echoed by Craig and Treptow (2020) as they outlined a framework for professional development in Indigenous education. The latter also included more specific strategies, including Elder teachings, site visits, team empowerment, "discursive strategies designed to facilitate a space to discuss the hard-to-talk-about topics," and action items (which they describe as "quick win" tools or actions participants can take back to their schools and easily implement) (Craig & Treptow, 2020). Webster-Wright (2009) also suggests that professional development (PD) move from passive and intermittent toward a more active, consistent practoce of professional learning. All of the above elements of effective PD should be considered in the development and delivery of any future anti-oppressive science teaching PD. In addition to these features, it is vitally important that anti-oppressive science PD is developed by or in close consultation with relevant marginalized communities and is responsive to the local context (Stewart, 2010; Thurber et al., 2019).

Over two-thirds of questionnaire participants in this study cited a lack of confidence in discussing sensitive topics as a barrier to implementing anti-oppressive

teaching. Participants expressed feeling apprehensive about addressing certain topics due to their lack of knowledge or expertise, along with concerns of potentially misrepresenting or offending. This agrees with the existing literature (Craig & Treptow, 2020; Le & Matias, 2019; Surette, 2019). There was also an apparent correlation between teachers' confidence levels and their willingness to address specific topics in their classrooms. Figure 4 shows the frequency with which teachers cover each topic, and Figure 6 shows teachers' self-reported confidence in addressing each topic. This phenomenon is consistent with the literature, which suggests that educators who do not feel confident in discussing or navigating discussions of oppression-related topics may avoid them altogether (Samuels, 2018; Surette, 2019).

The First Nations Education Steering Committee (2012) found that teachers lacked confidence in engaging with Indigenous pedagogy in particular and were anxious about "perpetuating misconceptions, making mistakes, or giving offence" while engaging in these topics. Focused, effective education and training may hold the solution to overcoming this lack of confidence. Chinn found a significant shift in teachers' perceptions of the connection between Indigenous knowledge and their science teaching after a ten-day immersive professional development session (2007). Some teachers who were at first resistant became more responsive after being presented with more information and engaging in discussion. Teachers went on to develop culturally relevant, place- and standards-based resources. Similarly, Ogunniyi noted that teachers who initially held prejudiced views around Indigenous knowledge systems and pedagogical practices improved their perception and confidence after attending a training module

(2004). It would therefore be reasonable to expect that improved training around issues of oppression in science would improve teachers' confidence and therefore promote engagement with these topics.

The evidence from this study and the cited literature collectively underscore the urgency of addressing the training and professional development needs of NLESD intermediate and secondary science teachers.

5.3.3 Standardized Curriculum and Time Constraints

Time constraints were overwhelmingly cited by participants as a major limiting factor in their implementation of anti-oppressive teaching. This was the most cited factor within the questionnaire data, with nearly 80% of respondents selecting it. When teachers elaborated through the constructed response section and through interviews, two distinct meanings emerged. In one sense, teachers were saying there was not enough time within the course to address such topics, and they felt rushed to cover the prescribed curriculum outcomes. In another sense, teachers indicated they lacked the prep time to research topics, find and develop resources, and plan lessons.

Teachers' feelings of being limited by the prescribed curriculum is a common theme in the literature. Chinn explains that even when teachers have the desire and the training to engage in anti-oppressive lessons, they often neglect it due to pressure to adhere to the official curriculum documents and to prioritize test scores (2007). It is, therefore, imperative that any initiatives to promote anti-oppressive teaching are supported by changes in curriculum. The Truth and Reconciliation Commission of

Canada, specifically Call to Action 10, has called on Canada's education systems to develop culturally appropriate curricula for Indigenous students (Truth and Reconciliation Commission of Canada, 2012). In 2017 *Now is the Time: A Report of the Premier's Task Force Improving Educational Outcomes* advocated for improved accessible curriculum (Collins et al., 2017). This report acknowledged the need for the Newfoundland and Labrador curriculum to be more responsive to students' interests and identities and specifically cited the importance of incorporating diverse representation in course materials across all disciplines.

Despite these recommendations and calls to action, the provincial intermediate and secondary science curriculum remains devoid of diverse representation and perspectives and continues to neglect socioscientific issues impacting marginalized communities. Many of the high school science curricula have been re-designed over the past five years, and while several opportunities exist for the explicit inclusion of anti-oppressive content, they have been largely ignored. For example, the current Biology 3201 curriculum was released in 2021 and although the course contains units on human reproduction and genetics, the concepts of gender and sexual diversity or of race or racism are not mentioned anywhere in the curriculum guide (NLDE, 2021). Table 8 below outlines a number of sample lesson topics which align with this biology curriculum and which could have provided opportunities for critical exploration of socioscientific issues and for anti-oppressive teaching.

Table 8

Sample of Potential Anti-Oppressive Topics Aligned with Biology 3201 Curriculum

Unit	Potential Opportunities For Anti-oppressive Lessons
Unit 1 Reproduction	○ Distinction between sex and gender. Acknowledgement of the complex nature of sex and of intersex and two-spirit identities ○ The role of homophobia in the initial response to the HIV epidemic, the lack of awareness re. recent advancements, & blood bans ○ Contributions of Percy Julian to the development of oral contraceptives & Dr. Henry Morgentaler to abortion access in Canada. ○ HeLa cells, Tuskegee syphilis trials, exploitation of Black women in early gynecological research (James Marion Sims). These provide opportunities to discuss Informed consent in medicine, exploitation of marginalized patients, scientific racism and race-based myths that continue to impact the health care of racialized folks today ○ Historic practice of forced sterilization of Indigenous women and others in Canada
Unit 2 Genetics	○ Curriculum currently lists Franklin, Watson & Crick re. development of the structure of DNA. Presents an opportunity to address the treatment of women in STEM ○ Above presents an opportunity to discuss controversy re. James Watson as a proponent of scientific racism and the ethical considerations of acknowledging scientists' beneficial as well as harmful legacies ○ Curriculum currently covers genetic differences but frames them only as disorders. Opportunity here to acknowledge these conditions as part of the natural variation of humanity and to incorporate a discussion of the social model of disability. ○ Recent updates to mapping of the human genome project to incorporate more diversity ○ Epigenetics provides an opportunity to discuss the potential intergenerational effects of slavery, residential schools, famine, etc

Unit 3 Evolution & Biodiversity	○ Contributions of Arab philosophers such as Al Jahiz and Ibn Khaldun to evolution. ○ Mary Anning is noted in the curriculum, opportunity to discuss the treatment of women in STEM and also classism and the uncredited contributions and labor of the working class in palaeontology ○ Taxonomy presents an opportunity to discuss Linnaeus's harmful contributions to the concept of race as a biological category and his role in setting the foundation of stereotypes that persist today ○ Georges Cuvier and Georges-Louis Leclerc, Comte de Buffon are noted in the curriculum & text. As Linnaeus and Watson this presents an opportunity to discuss the ethics of considering the harmful as well as beneficial contributions of scientists (racial studies and degeneration theory).

The topics noted in Table 8 above represent missed opportunities for anti-oppressive teaching in the Biology 3201 curriculum. This is an incomplete summary to demonstrate the potential within just one sample course. There are similar opportunities within other 7-12 science courses. The Science 1206 curriculum released in 2018, and the Biology 2201 curriculum, released in 2020, each contain units focused on ecology. However, neither of these curricula mention Indigenous ecological knowledge. Science 1206 also includes content on climate change, and Biology 2201 includes content on global populations and sustainability, but neither addresses the disproportionate impact of these issues on marginalized communities.

While most of the intermediate and secondary science curricula uphold oppression through neglect, some outcomes reinforce it in more direct ways. For example, the current Physics 2204 curriculum (released in 2018) contains a lesson in which students are expected to research the Muskrat Falls hydroelectric project. The

curriculum guide states that “Students should identify various constraints influencing the development of Muskrat Falls (i.e., costs, indigenous rights, societal concerns [methylmercury, north spur instability, ice formation, wildlife]) and recognize how these constraints have influenced the development of the project (NLDE, 2018)”. This quote is the only time the word “indigenous” appears in this curriculum document. Local Indigenous communities are not recognized in the curriculum for their significant role as stewards of the land or as legitimate, valuable stakeholders in decision-making processes. Instead, they are referenced only as one item in a list of constraints to development. Schaefli et al. (2019) conducted a review of curricula documents and textbooks in Newfoundland and Labrador as well as two other provinces and concluded that the resources tended to undermine Indigenous sovereignties and encourage students to model colonial dispossession. The authors argue that such lessons represent attempts to assert settler control over land and resources and they relate this to Canada and Newfoundland and Labrador’s heavy reliance on resource extraction (Schaefli et al., 2019). While the Schaefli et al. study did not examine science curricula or textbooks, this example from the Physics 2204 certainly supports their argument.

Because teachers often experience time constraints in covering the prescribed curriculum, expectations to address topics that fall outside of that curriculum create tension. This tension could be alleviated and engagement promoted if these important topics were prioritized and effectively integrated into curriculum design. In fact, many participants of this study directly expressed their desire to see issues of oppression addressed in the science curriculum. Teachers also noted feeling time constraints in terms

of finding and compiling resources and planning lessons. These constraints could be mitigated if teachers were provided with approved lesson plans and resources relevant to their respective curriculum areas and afforded sufficient PD time.

It bears repeating that any endeavour to examine or reform the curriculum, as well as any development or distribution of resources, must involve thorough and meaningful consultation and collaboration with relevant marginalized communities (Charlton, 1998; TFNESC, 2012). Representatives from relevant marginalized communities should not only be "at the table" so to speak, but should be directing the way.

5. 4 Discussion Summary

The results of this study begin to form an understanding of the current state of anti-oppressive teaching within Newfoundland and Labrador intermediate and secondary sciences. In short, there is a lack of consensus among educators around oppression in science and also around science education as a tool of anti-oppressive work. There is also considerable variation in the degree to which teachers practice anti-oppressive teaching within their science classes. These results appear to align with observations from existing research on anti-oppressive teaching across other regions and disciplines. The study outlines a number of areas for improvement and highlights best practices as provided in the literature. It is suggested that additional research in this area is warranted.

Further research would allow for the development of a more comprehensive picture and would be instrumental in the development of effective, authentic, and locally relevant initiatives to promote anti-oppressive science teaching. Future research with a

larger participant base could be used to validate and enrich the data acquired in this study. It could also facilitate inquiry into additional connections. For example, additional data might allow for a study of how teacher demographics influence perspectives on and/or the use of anti-oppressive practices. Participants in this study indicated that their personal experiences with oppression motivate them to focus on anti-oppressive teaching. It might therefore be expected that teachers from marginalized backgrounds may have unique perspectives on anti-oppressive teaching. Future research might also investigate how class demographics influences the use of anti-oppressive teaching. Further areas for inquiry could include student, guardian, school administrator or department personnel perspectives on anti-oppressive science teaching. Research to explore the effectiveness of professional development initiatives in the local context would also be valuable as would efforts to bring together scientists and science teachers from marginalized communities to develop relevant resources.

Chapter 6: Conclusion and Implications

The purpose of this study was to describe and critically analyze teachers' views on and use of anti-oppressive teaching in intermediate and secondary science in Newfoundland and Labrador. Specifically, the study sought to answer three research questions; (1) What are science teachers' views of oppression and anti-oppressive teaching in science? (2) To what extent and in what ways are teachers employing anti-oppressive science teaching? (3) What factors promote or limit teachers' implementation of anti-oppressive science teaching?

The results demonstrated significant variability among local teachers' perspectives on anti-oppressive teaching. Several participants expressed a lack of awareness in relation to oppression in science, and some expressed significant resistance to engaging with such topics. However, most participants claimed to feel a sense of responsibility to address these issues within their classes and expressed a strong desire to support marginalized students in science.

There was also considerable disparity observed in regard to teachers' application of anti-oppressive lessons and teaching strategies. The study found that, even among educators who do recognize the importance of these practices, implementation is inconsistent and often tends to focus on representation and diversity rather than addressing oppression directly.

The study revealed several factors which either promote or limit teachers' engagement with anti-oppressive teaching. Most notably, teachers cited a lack of training and the absence of such topics within the curriculum as constraints to their engagement. Consideration of these factors, together with existing literature, illuminated some key actions for advancing anti-oppressive science teaching in the province. These include;

1. Promotion of awareness and consensus among science teachers regarding the historic and ongoing relevance of oppression in science and science education.
2. Actions to investigate and address the teacher diversity gap and ensure that the diversity of the province's student population is reflected in the science teacher population
3. Enhanced teacher training and implementation of comprehensive and effective professional development on oppression and anti-oppressive teaching in science

4. Curriculum reform prioritizing anti-oppressive content in curriculum documents and approved course resources

The above items have emerged from this study and the literature as some important ways to promote anti-oppressive science teaching. Any measures must also be reflective of and responsive to the local context. The Government of Newfoundland and Labrador has endorsed initiatives of Safe and Caring Schools and Universal Design for Learning as well as other inclusion programs which have some degree of overlap with the principles of anti-oppressive teaching (n.d; 2023). However, as has been previously noted there has been no concerted program to promote anti-oppressive teaching in science whether within the curriculum or through professional development.

As has been reiterated throughout this study, endeavours to address this gap and to enhance engagement with anti-oppressive teaching can not be developed outside of authentic and sustained partnerships with relevant marginalized communities. The development of a more inclusive, equitable, and socially just science education will require a comprehensive, community approach. It is, therefore, not the intent of this study to prescribe a series of steps to promote anti-oppressive teaching in Newfoundland and Labrador. Instead, it is suggested that the information gathered from this study be used to simply begin a conversation, to demonstrate a need for more research and consideration, and to encourage collaboration among relevant stakeholders to promote anti-oppressive teaching in science within Newfoundland and Labrador and beyond.

References

500 women scientists leadership. (2020). Silence Is Never Neutral; Neither Is Science. https://blogs.scientificamerican.com/voices/silence-is-never-neutral-neither-is-science/

Abawi, Z., & Eizadirad, A. (2020). Bias-free or biased hiring? Racialized teachers' perspectives on educational hiring practices in Ontario. *Canadian Journal of Educational Administration and Policy*, 193, 18–31. https://journalhosting.ucalgary.ca/index.php/cjeap/article/view/68280

Adu-Boateng, S. (2019). *Examining the perspectives and practices of high school science teachers on inclusive pedagogy* (Doctoral dissertation, Memorial University of Newfoundland).

Aikenhead, G.S. (2000). Renegotiating the culture of school science. In R. Millar, J. Leach, & J. Osborne (Eds.), Improving science education: The contribution of research (pp. 245-264). Open University Press.

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. Teachers College Press.

Aikenhead, G., & Huntley, B. (1999). Teachers' views on aboriginal students learning Western and Aboriginal science. *Canadian Journal of Native Education, 23*(2), 159-175. https://doi.org/10.14288/cjne.v23i2.195864

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). "Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian

notions of capital beyond the arts. *Journal of Research in Science Teaching*, *52*(7), 922-948. https://doi.org/10.1002/tea.21227

Aveling, N. (2012). Critical engagement with whiteness: Beyond lecturing on the evils of racism. *Critical Voices in Teacher Education*, 22(2), 111-123. https://doi.org/10.1007/978-94-007-3974-1_8

Azam, S., & Goodnough, K. (2018). Learning together about culturally relevant science teacher education: Indigenizing a science methods course. *International Journal of Innovation in Science and Mathematics Education, 26*(2). https://openjournals.library.sydney.edu.au/CAL/article/view/12610

Bakshi, L. (2020). *Building an anti-racist science classroom*. *NSTA*. https://www.nsta.org/blog/building-anti-racist-science-classroom.

Barton, A., Schenkel, K., & Tan, E. (2021). Collaboratively engineering for justice in sixth grade STEM. *Journal of Research in Science Teaching*, *58*(7), 1010-1040. https://doi.org/10.1002/tea.21691

Beckwith, J. R. (2002). *Making genes, making waves*. Harvard University Press.

Belkhir, J. (1994). Race, sex, class & "intelligence" scientific racism, sexism & classism. *Race, Sex & Class*, 1(2), 53-83. http://www.jstor.org/stable/41680221

Bell, P. & Bang, M. (2015). Overview: How can we promote equity in science education? STEM Teaching Tools Initiative, Institute for Science + Math Education. Seattle, WA: University of Washington. http://stemteachingtools.org/brief/15

Bell, P. (2019) Infrastructuring teacher learning about equitable science instruction. *Journal of Science Teacher Education, 30*(7), 681-690. https://doi.org/10.1080/1046560X.2019.1668218

Bhandari, P. & Nikolopoulou, K. (2020). *Designing and analyzing Likert scales*. Scribbr. https://www.scribbr.com/methodology/likert-scale/

Blakeney, A. M. (2005). Antiracist pedagogy: Definition, theory, and professional development. *Journal of Curriculum and Pedagogy*, *2*(1), 119-132.

Block, C. J., Cruz, M., Bairley, M., Harel-Marian, T., & Roberson, L. (2019). Inside the prism of an invisible threat: Shining a light on the hidden work of contending with systemic stereotype threat in STEM fields. *Journal of Vocational Behavior*, *113*, 33-50. https://doi.org/10.1016/j.jvb.2018.09.007

Bottia, M. C., Mickelson, R. A., Jamil, C., Moniz, K., & Barry, L. (2021). Factors Associated With College STEM Participation of Racially Minoritized Students: A Synthesis of Research. *Review of Educational Research*, *91*(4), 614-648. https://doi.org/10.3102/00346543211012751

Brandes, G. M. & Kelly, D. M., (2004). Teaching for social justice: Teachers inquire into their practice. *Educational Insights*, *8*(3), 1-7. http://www.ccfi.educ.ubc.ca/publication/insights/v08n03/articles/teaching.htm

Brown, J. C. (2017). A metasynthesis of the complementarity of culturally responsive and inquiry‐based science education in K‐12 settings: Implications for advancing equitable science teaching and learning. *Journal of Research in Science Teaching*, *54*(9), 1143-1173. https://doi.org/10.1002/tea.21401

Broyles, P., & Fenner, W. (2010). Race, human capital, and wage discrimination in STEM professions in the United States. *International journal of sociology and social policy, 30* (5/6), 251-266. https://doi.org/10.1108/01443331011054226

Burke, L. E. C. A. (2022). Foregrounding intersectionality in considerations of diversity: Confronting discrimination in science teacher education. *Research in Science Education*, *52*(4), 1157-1170. https://doi.org/10.1007/s11165-021-10001-1

Cajete, G. A. (1999). The native american learner and bicultural science education. https://eric.ed.gov/?id=ED427908

Cech, E. A., & Waidzunas, T. J. (2021). Systemic inequalities for LGBTQ professionals in STEM. *Science Advances, 7*(eabe0933). https://doi.org/10.1126/sciadv.abe0933

Celikates, R., & Flynn, J. (2023). Critical theory (Frankfurt School). In E. N. Zalta & U. Nodelman (Eds.), *The Stanford Encyclopedia of Philosophy* (Winter 2023 edition). https://plato.stanford.edu/archives/win2023/entries/critical-theory/

Chan, E.C., Cheung, S.C., Kim, S.K., Lowe, M.L., Luu, K.L., McAuley, S.M., To, J.T., & Tran, M.T. (2020, December). Addressing anti-asian racism: A Resource for educators. https://www.tdsb.on.ca/Portals/0/docs/Addressing%20Anti-Asian%20Racism%20Resource%20Booklet%20final%20web%20Jan%2024.pdf

Charmantier, I. (2020). The Linnean Society. *Linnaeus and race*. https://www.linnean.org/learning/who-was-linnaeus/linnaeus-and-race

Charlesworth, T. E., & Banaji, M. R. (2019). Gender in science, technology, engineering, and mathematics: Issues, causes, solutions. *Journal of Neuroscience*, *39*(37),

7228-7243. https://doi.org/10.1523/JNEUROSCI.0475-18.2019

Charlton, J. I. (1998). *Nothing about us without us: disability oppression and empowerment*. University of California Press.

Chike, A. B. (2021). Karl Popper's critique of Thomas Kuhn's concept of normal science: An evaluation. *African Journal of Social Sciences and Humanities Research, 4*(3), 105-115.

Chinn, P. W. (2007). Decolonizing methodologies and indigenous knowledge: The role of culture, place and personal experience in professional development. *Journal of research in science teaching*, *44*(9), 1247-1268. https://doi.org/10.1002/tea.20192

Chowning, J., Osuga, H., Bryant, W. & Foster, J. (2022) Attending to race and identity in science Instruction. STEM teaching tools initiative, institute for science + Math Education. Seattle, WA: University of Washington. https://stemteachingtools.org/brief/89

Cech, E. A., & Pham, M. V. (2017). Queer in STEM organizations: Workplace disadvantages for LGBT employees in STEM related federal agencies. *Social Sciences*, *6*(1), 12. https://doi.org/10.3390/socsci6010012

Chinook Fund. (2015). General terms & forms of oppression. https://chinookfund.org/wp-content/uploads/2015/10/Supplemental-Information-for-Funding-Guidelines.pdf

Clough, S., & Orozco, J. (2016). Scientific sexism and racism. *The Wiley Blackwell Encyclopedia of Gender and Sexuality Studies*, 1-5. https://doi.org/10.1002/9781118663219.wbegss315

Cohen, J. (2006). Social, emotional, ethical, and academic education: Creating a climate for learning, participation in democracy, and well-being. *Harvard Educational Review, 76*(2), 201-237,285. https://doi.org/10.17763/haer.76.2.j44854x1524644vn

Collins, A., Fushell, M., Philpott, D., & Wakeham, M. (2017). The premier's task force on improving educational outcomes: Now is the time - The next chapter in education in Newfoundland and Labrador. https://www.ed.gov.nl.ca/edu/task_force/report.pdf

Craig, T. & Treptow, C. (2020). Improving indigenous students' success through an analysis and implementation of promising teaching practices. (Project No. 296). McDowell Foundation.https://www.nwsd.ca/Documents/296%20-%20Improving%20Indigenous%20Students'%20Success%20Final%20Report.pdf

Creswell, J. W., & Clark, V. L. P. (2007). *Designing and conducting mixed methods research*. Sage publications.

Creswell, J. (2012). *Educational research: planning, conducting, and evaluating quantitative and qualitative research* (4th edition). Pearson

Creswell, J.W. (2013). *Qualitative Inquiry & Research Design: Choosing Among the Five Approaches.* SAGE Publications, Inc.

Cudd, A. E. (2006). Analyzing oppression. Oxford University Press.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development.

https://www.yu.edu/sites/default/files/inline-files/Effective_Teacher_Professional_Development_REPORT.pdf

Davis, B., Sumara, D. & Luce-Kapler, R. (2015). Engaging minds: Cultures of education and practices of teaching (3rd ed.). Routledge

Dedotsi, S., & Paraskevopoulou-Kollia, E. (2019). Anti-oppressive education: Messages from paulo Freire. *Comunitania,* 18, 9-20. https://doi.org/10.5944/comunitania.18.1

DiCicco‐Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. Medical education, 40(4), 314-321. https://doi.org/10.1111/j.1365-2929.2006.02418.x

Eaton, A. A., Saunders, J. F., Jacobson, R. K., & West, K. (2020). How gender and race stereotypes impact the advancement of scholars in STEM: Professors' biased evaluations of physics and biology post-doctoral candidates. *Sex Roles*, *82*(3-4), 127-141. https://doi.org/10.1007/s11199-019-01052-w

Eisner, E. (1998). The enlightened eye: Qualitative inquiry and the enhancement of educational practice. Merrill.

Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *Journal of educational psychology*, *103*(1), 206–222. https://doi.org/10.1037/a0020743

Finson, K.D. (2002). Drawing a scientist: What we do and do not know after fifty years of drawings. *School Science and Mathematics, 102*(7), 335-345.

https://doi.org/10.1111/j.1949-8594.2002.tb18217.x

First Nations Education Steering Committee (TFNESC). (2012). In our words bringing authentic First peoples content to the K-3 classroom. https://www.fnesc.ca/learningfirstpeoples/k-3/

Freire, P., (2005). *Pedagody of the oppressed* (M. B. Ramos, Trans.; 30th Anniversary Edition). The Continuum International Publishing Group Ltd.

Fry, R., Kennedy, B., & Funk, C. (2021, April 1). *Stem jobs see uneven progress in increasing gender, racial and ethnic diversity*. Pew Research Center Science & Society. https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/

Funes, Y. (2018). Green science's white people problem. https://grist.org/article/environmental-science-diversity-asthma-aradhna-tripati-esteban-burchard/

Galamba, A., & Matthews, B. (2021). Science education against the rise of fascist and authoritarian movements: Towards the development of a pedagogy for democracy. *Cultural Studies of Science Education, 16*(2), 581-607. https://doi.org/10.1007/s11422-020-10002-y

Galloway, M. K., Callin, P., James, S., Vimegnon, H., & McCall, L. (2019). Culturally responsive, antiracist, or anti-oppressive? How language matters for school change efforts. *Equity & Excellence in Education*, *52*(4), 485-501. https://doi.org/10.1080/10665684.2019.1691959

Gardner, M., & Kelly, U. A. (Eds.). (2008). Narrating transformative learning in education. Palgrave Macmillan. https://doi.org/10.1057/9780230610576_1

Government of Newfoundland and Labrador. (n.d). Safe and Caring Schools https://www.gov.nl.ca/education/k12/safeandcaring/

Government of Newfoundland and Labrador. (2022). Learning in a Time of Change: Report of Teacher Allocation Review Committee. https://www.gov.nl.ca/education/files/Learning-in-a-Time-of-Change-Report-of-Teacher-Allocation-Review-Committee-2022.pdf

Government of Newfoundland and Labrador. (2023). NLESD Accessibility Plan. https://www.nlschools.ca/about/docs/NLS-AccessibilityPlan.pdf

Government of Newfoundland and Labrador. (2024). District Overview.https://www.nlschools.ca/about/districtoverview.jsp#:~:text=As%20of%20January%201%2C%202024,Over%2010%2C000%20employees.

Graves Jr, J. L., Kearney, M., Barabino, G., & Malcom, S. (2022). Inequality in science and the case for a new agenda. *Proceedings of the National Academy of Sciences*. https://doi.org/10.1073/pnas.2117831119

Guetterman, T. C., & James, T. G. (2023). A software feature for mixed methods analysis: The MAXQDA Interactive Quote Matrix. *Methods in Psychology*, *8*(12). https://doi.org/10.1016/j.metip.2023.100116

Halpin, Z. T. (1989). Scientific objectivity and the concept of "the other". *Women's Studies International Forum, 12*(3), 285-294). https://doi.org/10.1016/S0277-5395(89)80006-8

Hatcher, A., Bartlett, C., Marshall, A., & Marshall, M. (2009). Two-eyed seeing in the classroom environment: Concepts, approaches, and challenges. *Canadian Journal of Science, Mathematics and Technology Education*, *9*(3), 141-153. https://doi.org/10.1080/14926150903118342

Hauser, V., Howlett, C., & Matthews, C. (2009). The place of indigenous knowledge in tertiary science education: A case study of Canadian practices in indigenising the curriculum. *The Australian Journal of Indigenous Education*, *38*(S1), 46-58. https://doi.org/10.1375/S132601110000082X

Hoffman, K. M., Trawalter, S., Axt, J. R., & Oliver, M. N. (2016). Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between blacks and whites. *Proceedings of the National Academy of Sciences, 113*(16), 4296-4301. https://doi.org/10.1073/pnas.1516047113

hooks, b. (2014). *Teaching to transgress*. Education as practice of freedom. Routledge.

Horgan, J., & Horowitz, A. (2022). Refocusing science professional learning: social justice at the heart. *Cultural Studies of Science Education*, *17*(3), 907-913. https://doi.org/10.1007/s11422-022-10120-9

Institute of Physics, Royal Astronomical Society & Royal Society of Chemistry. (2019) Exploring the Workplace for LGBT+ Physical Scientists. https://www.rsc.org/globalassets/04-campaigning-outreach/campaigning/lgbt-report/lgbt-report_web.pdf

Janzen, M., & Cranston, J. (2016). The challenges of implementing a diversity admission policy. University Affairs.

https://universityaffairs.ca/opinion/in-my-opinion/challenges-implementing-diversity-admissions-policy/

Jegede, O. J., & Aikenhead, G. S. (1999). Transcending cultural borders: Implications for science teaching. *Research in Science & Technological Education, 17*(1), 45-66. https://doi.org/10.1080/0263514990170104

Johnson, D. R. (2012). Campus racial climate perceptions and overall sense of belonging among racially diverse women in STEM majors. *Journal of College Student Development*, *53*(2), 336-346. https://doi.org/10.1353/csd.2012.0028

Johnson, P. A., Widnall, S. E., & Benya, F. F. (2018). Sexual harassment of women: Climate, culture, and consequences in academic sciences, engineering, and medicine. https://doi.org/10.17226/24994

Kelly, D. (2012). Teaching for social justice: Translating an anti-oppression approach into practice. *Our Schools, our Selves, 21*, 135-154. Retrieved from https://qe2a-proxy.mun.ca/login?url=https://www.proquest.com/magazines/teaching-social-justice-translating-anti/docview/1035333918/se-2

Kelly, R. (2017). *Education 6100: Research Designs and Methods in Education* [Course Notes]. Memorial University of Newfoundland.

Kincheloe, J. Steinburg, S. (1997). *Changing multiculturalism.* Open University Press.

Kötter, M., & Hammann, M. (2017). Controversy as a blind spot in teaching nature of science. *Science & Education*, *26*(5), 451-482. https://doi.org/10.1007/s11191-017-9913-3

Kozlowski, D., Larivière, V., Sugimoto, C. R., & Monroe-White, T. (2022). Intersectional inequalities in science. Proceedings of the National Academy of Sciences, 119(2), e2113067119.

Kumashiro, K. K. (2000). Toward a theory of anti-oppressive education. *Review of Educational research*, *70*(1), 25-53. https://doi.org/10.2307/1170593

Kumashiro, K. K. (2002). Against repetition: Addressing resistance to anti-oppressive change in the practices of learning, teaching, supervising, and researching. *Harvard Educational Review, 72*(1), 67-92. https://doi.org/10.17763/haer.72.1.c11617526l7k46v6

Kumashiro, K. K., & Ngo, B. (2007). *Six lenses for anti-oppressive education: Partial stories, improbable conversations* (Vol. 315). Peter Lang.

Kumashiro, K. (2012). *Troubling education:" Queer" activism and anti-Oppressive pedagogy*. Routledge.

Lakhani, N. (2019). 'Racism dictates who gets dumped on': how environmental injustice divides the world. https://www.theguardian.com/environment/2019/oct/21/what-is-environmental-injustice-and-why-is-the-guardian-covering-it

Landivar, L.C. (2013). Disparities in STEM employment by sex, race, and hispanic origin. https://selectra.co.uk/sites/default/ files/pdf/stememployment.pdf

Laughter, J. C., & Adams, A. D. (2012). Culturally relevant science teaching in middle school. *Urban Education*, *47*(6), 1106-1134. https://doi.org/10.1177/0042085912454443

Le, P. T., & Matias, C. E. (2019). Towards a truer multicultural science education: How whiteness impacts science education. *Cultural Studies of Science Education*, *14*, 15-31. https://doi.org/10.1007/s11422-017-9854-9

Le Grange, L. (2004). Western science and indigenous knowledge: competing perspectives or complementary frameworks: perspectives on higher education? *South African Journal of Higher Education*, *18*(3), 82-91. https://www.ajol.info/index.php/sajhe/article/view/25482

Lehr, J. L. (2007). Why Social Justice Educators Must Engage Science in All of Our Classrooms. *Counterpoints*, *315*, 17–32. http://www.jstor.org/stable/42979123

Lewis, K. L., Stout, J. G., Pollock, S. J., Finkelstein, N. D., & Ito, T. A. (2016). Fitting in or opting out: A review of key social-psychological factors influencing a sense of belonging for women in physics. *Physical Review Physics Education Research*, *12*(2), 020110. https://doi.org/10.1103/physrevphyseducres.12.020110

Li, X., & Grineva, M. (2016). Academic and Social Adjustment of High School Refugee Youth in Newfoundland. *TESL Canada Journal*, *34*(1), 51-71. https://doi.org/10.18806/tesl.v34i1.1255

Lindsay, S., Kolne, K., Oh, A., & Cagliostro, E. (2019). Children with disabilities engaging in STEM: exploring how a group-based robotics program influences STEM activation. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(4), 387-397. http://dx.doi.org/10.1007/s42330-019-00061-x

Lodge, W. (2021). Confronting repressive ideologies with critical pedagogy in science classrooms. *Cultural Studies of Science Education*, *16*(2), 609-620. https://doi.org/10.1007/s11422-021-10047-7

Longbottom, J. E., & Butler, P. H. (1999). Why teach science? Setting rational goals for science education. *Science Education*, *83*(4), 473-492. https://doi.org/10.1002/(SICI)1098-237X(199907)83:4<473::AID-SCE5>3.0.CO;2-Z

Long, S. (2019). Growing a Gender-inclusive biology curriculum: A framework and reflections for secondary science teachers. *The Assembly*, *2*(1), 5-10. https://journals.colorado.edu/index.php/assembly/article/view/481/449

Long, S., Steller, L., Suh, R., Butler, K., & Slattery, K. (2021). How do we present gender, sex, and sexuality as part of inclusive and accurate science teaching? STEM Teaching Tools Initiative, Institute for Science + Math Education. Seattle, WA: University of Washington. https://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-76-Gender-Inclusive-Science.pdf

Macdonald, C. (2020, August 10). The Dark Side of being a female shark researcher. Scientific American. https://www.scientificamerican.com/article/the-dark-side-of-being-a-female-shark-researcher/

Martin, K. A. (1993). Gender and sexuality: Medical opinion on homosexuality, 1900-1950. *Gender & Society*, *7*(2), 246-260.

Merriam-Webster. (n.d.). Oppression. In Merriam-Webster.com dictionary. Retrieved February 1, 2024, from https://www.merriam-webster.com/dictionary/oppression

McCoy, D. L., Winkle-Wagner, R., & Luedke, C. L. (2015). Colorblind mentoring? Exploring white faculty mentoring of students of color. *Journal of Diversity in Higher Education*, *8*(4), 225. https://doi.org/10.1037/a0038676

Milne, E. (2016). "I Have the Worst Fear of Teachers": Moments of Inclusion and Exclusion in Family/School Relationships among Indigenous Families in Southern Ontario. *Canadian Review of Sociology/Revue canadienne de sociologie*, *53*(3), 270-289. https://doi.org/10.1111/cars.12109

Mohr, J.A. (2010). Oppression by scientific method: The use of science to "other" sexual minorities. *Journal of Hate Studies, 77* (22): 21-45. https://pdfs.semanticscholar.org/a7bf/a5b6f7f1d68ba267d1ed65ae3605f901ce76.pdf

Moisio, OP. (2013). Critical theory. In Runehov, A.L.C., Oviedo, L. (eds) *Encyclopaedia of sciences and religions*. Springer. https://doi.org/10.1007/978-1-4020-8265-8_1642

Morales‐Doyle, D. (2017). Justice‐centered science pedagogy: A catalyst for academic achievement and social transformation. Science Education, 101(6), 1034-1060. http://dx.doi.org/10.1002/sce.21305

Morrison, D., Bell, P., Chowing, J., Klein, E. (2017). Addressing controversial science topics in the K-12 classroom. STEM Teaching Tools Initiative, Institute for

Science + Math Education. Seattle, WA: University of Washington. https://stemteachingtools.org/brief/44

Morrison, D. & Bell, P. (2018). How to build an equitable learning community in your science classroom. STEM Teaching Tools Initiative, Institute for Science & Math Education. Seattle, WA: University of Washington. https://stemteachingtools.org/brief/54

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. *Nursing Research, 40*(2), 120–123.

Napper, S. A., Hale Jr, P. N., & Puckett, F. J. (2002). Motivating students with disabilities to prepare for SEM careers. *Journal of Engineering Education*, *91*(3), 361-365. https:// onlinelibrary-wiley-com.qe2a-proxy.mun.ca/doi/epdf/10.1002/j.2168-9830.2002.tb00716.

Nash, M. (2021). National Antarctic Program responses to fieldwork sexual harassment. Antarctic Science, 33(5), 560–571. https://doi.org/10.1017/S0954102021000432

Nelson‐Barber, S., & Estrin, E. T. (1995). Bringing Native American perspectives to mathematics and science teaching. *Theory into practice*, *34*(3), 174-185. https://doi.org/10.1080/00405849509543677

Newfoundland and Labrador Department of Education, (2004). Biology 3201 [Program of studies]. https://www.gov.nl.ca/education/files/k12_curriculum_guides_science_bio3201_toc.pdf

Newfoundland and Labrador Department of Education, (2021). Science Curriculum [Program of studies].

https://www.gov.nl.ca/education/k12/curriculum/guides/science/

NLTA. (2019). Class Size Matters. [Media Release]. https://www.nlta.nl.ca/wp-content/uploads/2019/10/Class-Size-Matters-Oct-31-20191.pdf

NSTA. (2019). Gender equity in science education. https://www.nsta.org/nstas-official-positions/gender-equity-science-education

Ogunniyi, M. B. (2004). The challenge of preparing and equipping science teachers in higher education to integrate scientific and indigenous knowledge systems for learners: the practice of higher education. *South African Journal of Higher Education*, *18*(3), 289-304. https://www.ajol.info/index.php/sajhe/article/view/25498

Okun, M. A.; Kwan, V. S. 2016. The effects of a female role model on academic performance and persistence of women in STEM courses. *Basic and Applied Social Psychology, 38(*5), 258-268. https://doi.org/10.1080/01973533.2016.1209757

Palmer, P. J. (2017). *The courage to teach: Exploring the inner landscape of a teacher's life*. John Wiley & Sons.

Paterson, K. (2023). Learning to teach for equity, diversity, and social justice: A mixed methods case study of initial teacher education in Ontario, Canada [Doctoral dissertation, University of Western Ontario]. Electronic Thesis and Dissertation Repository. https://ir.lib.uwo.ca/etd/9740

Perkowitz, S. (2021). The Bias in the Machine: Facial Recognition Technology and Racial Disparities. *MIT Case Studies in Social and Ethical Responsibilities of Computing*, *Winter 2021*. https://doi.org/10.21428/2c646de5.62272586

Rainey, K., Dancy, M., Mickelson, R., Stearns, E., & Moller, S. (2018). Race and gender differences in how sense of belonging influences decisions to major in STEM. *International Journal of STEM Education*, *5*(1), 10. https://doi.org/10.1186/s40594-018-0115-6

Reverby, S. M. (Ed.). (2012). *Tuskegee's truths: rethinking the Tuskegee syphilis study*. UNC Press Books.

Rezende, F., & Ostermann, F. (2020). Hegemonic and counter-hegemonic discourses in science education from the perspective of a post-critical curriculum theory. *Cultural Studies of Science Education*, *15*(3), 679-694. https://doi.org/10.1007/s11422-019-09945-8

Rossiter, M. W. (1993). The Matthew Matilda Effect in Science. Social Studies of Science, 23(2), 325–341. https://doi.org/10.1177/030631293023002004

Rousso, H. (2008). Role models, mentors and muses for women with disabilities. *Impact: Feature Issue on Employment and Women With Disabilities*, *21*(1),8-9. https://ici.umn.edu /products/impact/211/6.html

Rudolph, J. L. (2000). Reconsidering the'nature of science'as a curriculum component. Journal of curriculum studies, 32(3), 403-419.

Samuels, A. J. (2018). Exploring Culturally Responsive Pedagogy: Teachers' Perspectives on Fostering Equitable and Inclusive Classrooms. *Srate Journal*,

27(1), 22-30.

Santos, W. L. D. (2009). Scientific literacy: A Freirean perspective as a radical view of humanistic science education. *Science Education*, *93*(2), 361-382.

Saunders, L., & Wong, M. A. (2020, August 1). *Critical pedagogy: Challenging bias and creating inclusive classrooms*. Illinois Open Publishing Network. https://iopn.library.illinois.edu/pressbooks/instructioninlibraries/chapter/critical-pedagogy-challenging-bias-and-creating-inclusive-classrooms/

Schaefli, L., Godlewska, A., & Lamb, C. (2019). Securing Indigenous dispossession through education: An analysis of Canadian curricula and textbooks. *Geographies of schooling*, 145-161.

Schindel Dimick, A. (2016). Exploring the potential and complexity of a critical pedagogy of place in urban science education. *Science Education*, *100*(5), 814-836.

Seidel, J. & Jardine, D. W. (2014). Introduction and a Curriculum for Miracles. In: Ecological Pedagogy, Buddhist Pedagogy, Hermeneutic Pedagogy: Experiments in a Curriculum for Miracles (J. Seidel & D.W. Jardine Eds.) New York, NY: Peter Lang Publishing Inc.

Sheth, M. J. (2019). Grappling with racism as foundational practice of science teaching. Science Education, 103(1), 37-60.

Skinner, D. (2020). Race, racism and identification in the era of technosecurity. *Science as Culture*, *29*(1),77-99.https://www.tandfonline.com/doi/abs/10.1080/09505431.2018.1523887

Smith, J. L., Cech, E., Metz, A., Huntoon, M., & Moyer, C. (2014). Giving back or giving up: Native American student experiences in science and engineering. *Cultural Diversity and Ethnic Minority Psychology*, *20*(3), 413. https://psycnet.apa.org/doiLanding?doi=10.1037%2Fa0036945

Snapp, S. D., Burdge, H., Licona, A. C., Moody, R. L., & Russell, S. T. (2015). Students' perspectives on LGBTQ-inclusive curriculum. *Equity & Excellence in Education*, *48*(2), 249-265. https://www-tandfonline-com.qe2a-proxy.mun.ca/doi/citedby/10.1080/10665684.2015.1025614?scroll=top&needAccess=true

Snively, G., & Williams, L. W. (2018). *Knowing home: Braiding indigenous science with Western science, Book 2*. ePublishing Services, University of Victoria Libraries.

Solomona, R. P., Portelli, J. P., Daniel, B. J., & Campbell, A. (2005). The discourse of denial: How white teacher candidates construct race, racism and 'white privilege'. *Race ethnicity and education*, *8*(2), 147-169.

Souto-Manning, M., & Hanson Mitchell, C. (2010). The Role of Action Research in Fostering Culturally-Responsive Practices in a Preschool Classroom. Early Childhood Education Journal, 269-277.

Spang, M., & Bang, M. (2015). Teaching STEM in ways that respect and build upon Indigenous peoples' rights. *STEM Teaching Tools 10*. Retrieved from https://stemteachingtools.org/brief/10

Spettel, S., & White, M. D. (2011). The portrayal of J. Marion Sims' controversial surgical legacy. *The Journal of urology*, *185*(6), 2424-2427.

Stahl, N. A., & King, J. R. (2020). Expanding approaches for research: Understanding and using trustworthiness in qualitative research. *Journal of developmental education*, *44*(1), 26-28.https://files.eric.ed.gov/fulltext/EJ1320570.pdf

Statistics Canada. (2017, November 1). *Immigration and ethnocultural diversity highlight tables*. Visible minority 2016 Census. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/imm/Table.cfm?Lang=E&T=41&Geo=00&SP=1&vismin=15&age=1&sex=1

Stavrou, S. G., & Miller, D. (2017). Miscalculations: Decolonizing and anti-oppressive discourses in indigenous mathematics education. *Canadian Journal of Education, 40*(3), 92-122. https://search-proquest-com.qe2a-proxy.mun.ca/docview/1952361626?accountid=12378

St Clair, D., & Kishimoto, K. (2010). Decolonizing Teaching: A Cross-Curricular and Collaborative Model for Teaching about Race in the University. *Multicultural Education*, *18*(1), 18-24.https://qe2a-proxy.mun.ca/login?url=https://www.proquest.com/scholarly-journals/decolonizing-teaching-cross-curricular/docview/856590320/se-2

Stewart, G. (2010). Knowing our place: Critical multicultural science education. *Critical Multiculturalism: From theory to praxis*. https://ebookcentral-proquest-com.qe2a-proxy.mun.ca/lib/mun/reader.action?docID=484743

Strayhorn, TL (2012). *College students' sense of belonging: a key to educational success for all students*. Routledge.

Sulz, L., Davis, M., & Damani, D. (2023). “Are we there yet?” An Examination of Teacher Diversity Within Canada’s Physical and Health Education Community. *Revue phénEPS/PHEnex Journal*, *13*(2). https://ojs.acadiau.ca/index.php/phenex/article/view/4349

Surette, T. (2019). Too scared to teach: secondary students’ insights into educators silencing and stigmatization of gender and sexual diversity in public schools in Alberta, Canada. *Journal of Contemporary Issues in Education*, *14*(2), 33-49.

Sutherland, D., & Swayze, N. (2012). The importance of place in indigenous science education. *Cultural Studies of Science Education*, *7*(1), 83-92. https://doi.org/10.1007/s11422-011-9371-1

Taylor, E. (2016). Groups and oppression. *Hypatia*, *31*(3), 520-536.

Teddlie, C., & Tashakkori, A. (2006). A general typology of research designs featuring mixed methods. *Research in the Schools, 13*(1), 12-28.

Terry, J. (1999). *An American obsession: Science, medicine, and homosexuality in modern science.* University of Chicago

Thurber, A., Harbin, M.B., & Bandy, J. (2019). Teaching Race: Pedagogy and Practice. Vanderbilt University Center for Teaching. https://cft.vanderbilt. edu /teaching-race/

Thompson, J., Mawyer, K., Johnson, H., Scipio, D., & Luehmann, A. (2021). C²AST (Critical and Cultural Approaches to Ambitious Science Teaching). *The Science Teacher*, *89*(1), 58-65.

Tite, R. (2010). Coming to Qualitative Research ED 6466: Qualitative Research

Methods. Memorial University of Newfoundland.

Tomkins, J. (2002). Learning to see what they can't: Decolonizing perspectives on Indigenous education in the racial context of rural Nova Scotia. *McGill Journal of Education / Revue Des Sciences De l'éducation De McGill*, *37*(003). Retrieved from https://mje.mcgill.ca/article/view/8646

Troudi, S. (2020) (Ed.). *Critical Issues in Teaching English and Language Education: International Research Perspectives.* Palgrave Macmillan

Truth and Reconciliation Commission of Canada. (2012). *Truth and Reconciliation Commission of Canada: Calls To Action*. https://ehprnh2mwo3.exactdn.com/wp-content/uploads/2021/01/Calls_to_Action_English2.pdf

Truth and Reconciliation Commission of Canada. (2015). *Final Report of the Truth and Reconciliation Commission of Canada, Volume One: Summary: Honouring the Truth, Reconciling for the Future*. James Lorimer & Company. https://ehprnh2mwo3.exactdn.com/wp-content/uploads/2021/01/Executive_Summary_English_Web.pdf

Turner Consulting Group. (2015). Voices of Ontario Black educators: An experiential report. https://onabse.org/ONABSE_VOICES_OF_BLACK_EDUCATORS_Final_Report.pdf

United Nations. (2007). United Nations Declaration on the Rights of Indigenous Peoples. https://www.un.org/esa/socdev/unpfii/documents/DRIPS_en.pdf

Upadhyay, B., Atwood, E., & Tharu, B. (2020). Actions for sociopolitical consciousness in a high school science class: A case study of ninth grade class with predominantly indigenous students. *Journal of Research in Science Teaching*, *57*(7), 1119-1147.

Valdez, V. E. (2022). *Teacher Educator and Preservice Teachers' Efforts to Enact Justice-Centered Science Pedagogy During Covid-19*. University of California, Santa Barbara.

Wakely, E. and Carson, J. (2011), "Historical recovery heroes – Isaac Newton", *Mental Health and Social Inclusion*, Vol. 15 No. 3, pp. 122-128.

Webster-Wright, A. (2009). Reframing professional development through understanding authentic professional learning. *Review of educational research*, *79*(2), 702-739. https://files.eric.ed.gov/fulltext/EJ1047338.pdf

Wing Sue, D., Torino, G. C., Capodilupo, C. M., Rivera, D. P., & Lin, A. I. (2009). How White Faculty Perceive and React to Difficult Dialogues on Race: Implications for Education and Training. *The Counseling Psychologist*, *37*(8), 1090–1115. https://doi.org/10.1177/ 0011000009340443

Whitt, E. J. (1991). Artful Science: A Primer on Qualitative Research Methods. *Journal of College Student Development*, *32*(5), 406-15.

Women in Science and Engineering Newfoundland and Labrador. (n.d.). *Missions and Goals*. WISE NL. https://wisenl.ca/about-us/overview/

Yin, R. K. (2006). Mixed methods research: Are the methods genuinely integrated or merely parallel. Research in the Schools, 13(1), 41-47.

Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: Theory and practice. *Journal of elementary science education*, *21*(2), 49-58.

Appendix A: Ethics Approval Form

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/human/icehr

ICEHR Number:	**20230961-ED**
Approval Period:	December 1, 2022 – December 31, 2023
Funding Source:	
Responsible Faculty:	Dr. Saiqa Azam Faculty of Education
Title of Project:	*Anti-oppressive Science Teaching: An Investigation of Intermediate and Secondary Science Teachers' Views and Practices*

December 1, 2022

Nikita Stapleton
Faculty of Education
Memorial University

Dear Nikita Stapleton:

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 **December 31, 2023**. 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

Appendix B: Participant Recruitment Letter

Email Subject Line: Invitation to Participate in Research Study [Anti-Oppressive Science Teaching Study]

Dear Science Teachers

I am a science teacher currently employed within NLESD and a Master of Education student at Memorial University of Newfoundland and Labrador. I am currently engaged in a research project which seeks to understand **teachers' views on and use of anti-oppressive teaching in intermediate and secondary science classrooms.** Note: Other terms related to this which you may be more familiar with may include anti-racist, decolonizing, social justice, or culturally responsive teaching.

I am seeking intermediate and secondary science teachers within NLESD to complete an **anonymous 3-5 minute questionnaire via the google form** linked below. Your participation in this research study is completely voluntary. Participation is not a school or school board requirement. There is a consent letter at the top of the google form, and consent is assumed upon completing and submitting the questionnaire.

Following the questionnaire, teachers may indicate if they would like to be contacted for an approximately 30-minute follow-up interview to be completed at their convenience via google meet. If you agree to participate in the interview portion, you will be forwarded a consent form with additional details and will have the opportunity to ask any questions about the project. Interviews will be audio-recorded. Interview participants will also have the opportunity to share any relevant lesson plans or resources if they choose. The questionnaire will be anonymous, and the interview data will be anonymized before analysis. Raw data will be kept secure and will only be accessible to the principal investigator and the research supervisor. Interview participants may withdraw from the research study on or before the cut-off date of March 15, 2023, in which case any information gathered from you will be discarded and not used in the research study.

If you have any questions about the research, please feel free to contact me at nikitastapleton@nlesd.ca or my supervisor Dr. Azam at sazam@mun.ca.

Link to teacher questionnaire: https://forms.gle/dFxnSxqZLB7wdazUA

Thank you in advance for considering this request.

Sincerely,
Nikita Stapleton
Faculty of Education
Memorial University of Newfoundland
St John's, NL, A1B 3X8
Email: nikitastapleton@nlesd.ca

Appendix C: Informed Consent Form

Title: Anti-oppressive Science Teaching: An Investigation of Intermediate and Secondary Science Teachers' Views and Practices

Principal Investigator

Nikita Stapleton, B.Sc, B.Ed
M.Ed Student
Faculty of Education, Memorial University of Newfoundland and Labrador
St John's NL, Canada, A1B 3X8
Email: nikitastapleton@nlesd.ca

Research Supervisor

Saiqa Azam, PhD
Associate Professor
Faculty of Education, Memorial University of Newfoundland and Labrador
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 Anti-oppressive Science Teaching: An Investigation of Intermediate and Secondary Science Teachers' Views and Practices.

This form is part of the process of informed consent. It outlines what the research is about and what your participation will involve. It also describes your right to withdraw from the study. In order 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. Please contact the principal investigator or supervisor if you have any questions before you consent.

Introduction:
I (Nikita Stapleton) am a teacher with NLESD and a Master of Education student in the Faculty of Education, Memorial University of Newfoundland. Dr. Azam is an Associate Professor of Science Education in the Faculty of Education, at Memorial University of Newfoundland and Labrador.

We are currently engaged in a research project which seeks to understand **teachers' views on and use of anti-oppressive teaching in intermediate and secondary science classes**. This stage of the research project involves a brief, anonymous questionnaire to be completed via google form.

Purpose of the study:
The purpose of this research is to investigate teachers' views on and use of anti-oppressive teaching in intermediate and secondary science classrooms.

What you will do in this study:
If you agree to be part of this research phase, you will be asked to:

1. Complete a 3-5 minute, anonymous questionnaire via google form
    a. You may skip any questions which you prefer not to respond to

Note: Upon completion of the questionnaire, you will have the option to participate in a follow-up interview. If you agree, your email will be collected in a separate window and will not be tied to questionnaire data. It is not a requirement that you provide your email address or participate in the interview phase.

Withdrawal from the study:

Your participation in this study is completely voluntary, and you may withdraw from the study at any time before submission of the questionnaire by simply closing the web browser. After submission, the data will be anonymous and it will not be possible to isolate your data to discard it.

Possible Benefits:

The proposed research will make a contribution to the literature on teaching science in the context of social justice. The proposed research will also contribute to teachers, schools, and relevant organizations' understanding of current teacher views, practices, and needs in relation to anti-oppressive science teaching.

Possible risks:

Teachers may experience emotional/psychological risks when answering questions about how they conduct their work. Teachers are encouraged to access their employee assistance program and/or a counselling resource line if needed.

Confidentiality:

All the data will be confidential and anonymous. Data will be kept in a password-protected google drive folder in MUN managed account.

Anonymity:

This questionnaire is anonymous and does not collect participants' names or email addresses. However, being members of a small specialized community in the school district, there is a possibility that the researcher may be able to identify you as a participant based on responses to demographic and background questions Every effort will be made to ensure anonymity in the publication of any data collected in this research project.

Storage of Data:

The digital data will be stored in a password-protected google drive folder in an account managed by MUN. Data will only be available to the principal investigator and research supervisor. The data will be stored for a minimum of five years, as required by Memorial University's policy on Integrity in Scholarly Research.

Reporting of Results:
The data from this research project will be published and presented at scholarly conferences and in journals. In these reports, the data will be presented in summarized form, and all identifying information will be removed from the research report. Upon completion, this thesis will be available at Memorial University's Queen Elizabeth II library, and can be accessed online at:
http://collections.mun.ca/cdm/search/collection/theses.

Sharing of Results with Participants:
The research report based on the data collected will be made accessible to all the teacher participants via the online folder: Anti-Oppressive Study Publications

Questions:
You are welcome to ask questions at any time before, during, or after your participation in this research. If you would like more information about this study, you may contact the principal investigator or research supervisor as per the contact information above.

Consent:
Completion and submission of this questionnaire mean that:

- You have read the information about the research.
  You understand what the study is about and what you will be doing.
- You agree to participate in the research project understanding the risks and contributions of your participation, that your participation is voluntary.
- You are free to withdraw participation in the study without having to give a reason
- You may withdraw at any time from the start of the questionnaire until submission
- Clicking submit at the end of this questionnaire confirms your consent to participate.

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 D: Questionnaire

Anti-oppressive Science Teaching: An Investigation of Intermediate and Secondary Science Teachers' Views and Practices Questionnaire

Reminder: Participation is voluntary, participants are free to withdraw at any time by closing the browser and are free to skip any questions they do not wish to respond to

1. What is your current employment status:

- Substitute
- Replacement
- Permanent probationary
- Permanent tenured

2. How long have you taught intermediate/ secondary science?

- 0 - 4 years
- 5 - 10 years
- 10 + years

3. Which science course(s) have you taught within the past 3 years?

- Science 7
- Science 8
- Science 9
- Science 1206
- Biology 2201
- Biology 3201
- Chemistry 2202
- Chemistry 3202
- Physics 2204
- Physics 3204
- Environmental Science 3205
- Earth systems 3209
- Science 2202
- Science 3202
- Other:

4. Do you self-identify as any of the following?

- Disabled
- Indigenous
- Racialized minority
- Queer / 2SLGBTQ+
- Woman
- Other marginalized population:
- Prefer not to disclose

5. To what extent do you agree with the following statements:

1- Strongly Disagree 5- Strongly Agree

Statement	1	2	3	4	5
i. Science is equally accessible to all people					
ii. The products of science benefit all people equally					
iii. Science has historically upheld inequity and/or oppression					
iv. Science currently upholds inequity and/or oppression					
v. I feel responsible for discussing or confronting inequity and oppression in my science classroom					
vi. I don't think issues of oppression should be addressed within science classes					
vii. Existing science curriculum and resources include diverse voices and perspectives from marginalized communities.					
iix. Existing science curricula and resources support the inclusion of anti-oppressive lessons					

6. How frequently do you address the following topics in your science classroom

Scale Never 1 2 3 4 5 Multiple lessons per unit

Ableism in science

Indigenous issues in science

Racism in science

Sexism in science

Queer issues in science

7. How confident are you in discussing the following topics in your science classroom

Scale Not confident 1 2 3 4 5 Very confident

Ableism in science

Indigenous issues in science

Racism in science

Sexism in science

Queer issues in science

8. In which format(s) do you address these issues in your science classroom?
   - Rarely addressed
   - Inclusion of resources that celebrate diversity in science
   - Informal class discussions about inequality/ oppression in science
   - Presentations and partnerships with community groups addressing oppression
   - Lessons designed intentionally to confront oppression in science
   - Other

9. What factors, if any, limit your implementation of these lessons?
   - Confidence in discussing sensitive topics
   - Time constraints
   - Lack of training or preparation
   - Perceived priorities of school administration
   - Perceived priorities of school district
   - Perceived priorities of guardians
   - Other:

10. Within the science courses you teach, which units and topics do you feel provide opportunities to address issues of oppression?

11. Any last thoughts or reflections that you would like to share that were not invited in the above questions

Appendix E: Interview Questions

Interview Script

Anti-oppressive Science Teaching: An Investigation of Intermediate and Secondary Science Teachers' Views and Practices

Reminder: Participation is voluntary, participants are free to end the interview at any time and are free to skip any questions they do not wish to respond to

Demographic Questions

1. What is your current employment status?
2. How long have you taught intermediate /secondary science?
    a. Do you have any other science teaching experiences? [probes: Post Secondary, informal education etc]
3. Which science course(s) have you taught within the past 3 years?
4. Do you teach any courses outside of science? If so, list.

Knowledge & Attitude

5. What is your understanding of Oppression?
   [Probing Questions: Do you think oppression is more of a historical issue or ongoing, which identities if any, do you believe are currently oppressed]

    a. How do you think this relates to science? Provide any examples.

6. What is your understanding of anti-oppressive teaching? Provide any examples
   [Probing Questions: How can teachers' practices and lessons address, confront or even re-enforce oppression?]

    a. How do you think this relates to science? Provide any examples.

7. Marginalized populations are groups or communities that lack some representation, rights, or resources that typically are afforded other populations. Which populations, if any, do you feel have been marginalized within fields of science and how?

Teacher Preparation & Training

8. Have you been offered training or professional learning related to anti-oppressive

teaching? (Terms associated with this concept might include decolonized, anti-racist, culturally responsive, social justice teaching etc.)

a. If yes, please provide some detail on the content of the training, what you found most useful and what you felt was lacking.

b. Did these sessions include content specific to science teaching?

Teacher Practices

9. Which elements of your classroom design, management, or routines do you feel support an anti-oppressive learning environment?

10. Do you or have you in the past implemented lessons which address the following topics in your science classes? If yes, please describe the unit, topic, and lesson.
    a. Racism
    b. Sexism
    c. Indigenous issues
    d. Queer issues
    e. Disabilities/ ableism

11. What factors promote you to implement these practices or lessons?
[Probes: How do your personal experiences influence you? How do students, guardians, other teachers, or the administration influence you? How do curriculum expectations influence you?]

12. What factors limit or inhibit you from implementing these practices or lessons? What concerns or challenges do you have?

13. Would you like to implement more anti-oppressive lessons than you currently do?
    a. If yes, what support(s) would you need in order to achieve this?
    b. If yes, what units or topics do you feel provide the best opportunities for this?

14. Any last thoughts or reflections that you would like to share that were not invited in the above questions?