Abstract

In this qualitative research study, I examine eight elementary educators perspectives on teaching science to diverse students in the Greater Toronto Area (GTA). A critical pedagogy and antiracism conceptual framework is used to examine elementary educators perspectives on the interrelationship between student sociocultural background and science education. Ontario Ministry of Education policies and curriculum documents and science educational research are used to interpret themes/codes from the official literature on student diversity and science education. Key findings of my research study show that: (1) elementary educators’ are ‘socio-culturally conscious’ of diverse students in the science classroom; (2) elementary educators require a more complex and broader understanding of official discourses on the sociocultural contexts of science education and implications for scientific literacy development; and (3) professional development (i.e., workshops and training) and teacher collaboration opportunities are identified as effective strategies for supporting elementary educator in diverse science classroom spaces.
Acknowledgements

First, I would like to thank my Thesis Supervisor Dr. Diane Gérin-Lajoie for going above and beyond and providing the guidance, support, motivation, and dedication necessary to successfully complete my research study. Also, I am very grateful to Dr. Wanja Gitari for providing critical and insightful reflections on my thesis, which has allowed me to grow as a qualitative researcher.

To the participants of my study, I am forever indebted to you, because without your willingness to share your ideas, opinions, and perspectives this study would not be possible. Thank you for giving me the opportunity to learn from you.

At times my ‘Grad Life’ journey has been challenging, especially as a part-time student and full-time middle school teacher. I would have never survived this process without the support and love of my beautiful parents. Mom and dad, I love you and without your kind words and overall faith in me I would not have been successful.

Last but not least, to my love, Wyatt Michael Mackenzie Burke, thank you for your patience. I am now ready to become Mrs. Burke; I can’t wait for summer 2013!

For those who may read my thesis, I believe that individually and collectively we must strive for excellence and equity in our school systems and ensure that all students are afforded the opportunities to ‘learn without barriers’. So, read, get inspired, and join the movement!
Table of Contents

Abstract ................................................................................................................................. ii
Acknowledgements ................................................................................................................... iii
Table of Contents ...................................................................................................................... iv

Chapter One: Introduction to the Study ............................................................................... 1
1.1 Statement of Purpose and Research Question ................................................................. 3
1.2 Overview of Research Study .............................................................................................. 4

Chapter Two: Literature Review ......................................................................................... 6
2.1 Context of Diversity Policies in Ontario Schools and Science Education ......................... 6
2.2 Elementary Educators and Science Education .................................................................. 12
2.3 Science Education Models ................................................................................................. 16
2.3.1 Universalism .................................................................................................................. 16
2.3.2 Multiculturalism ............................................................................................................. 18
2.4 Access to School Science ................................................................................................. 21
2.4.1 Urban Schools and Science Education ....................................................................... 23
2.4.2 Language and Science Education .............................................................................. 26
2.5 Conceptual Framework: Critical Pedagogy and Antiracism ............................................. 31

Chapter Three: Research Methodology ............................................................................. 38
3.1 Qualitative Research ......................................................................................................... 38
3.2 Semi-structured Interviews ............................................................................................. 39
3.3 Document Analysis .......................................................................................................... 40
3.4 Data Collection ................................................................................................................ 41
3.5 Data Analysis .................................................................................................................... 42
3.6 Ethical Considerations .................................................................................................................. 44

Chapter Four: Document Analysis ................................................................................................. 46
4.1 Section 1: Equity and Inclusive Education Policies in Ontario .............................................. 46
4.2 Section Two: The Role of the Educator in Addressing Student Diversity Issues ............. 54

Chapter Five: Participant Profiles and Elementary Educators Knowledge of
Student Diversity Issues in Science Education ............................................................................. 67
5.1 Section 1: Study Participants’ Background Information ......................................................... 67
5.2 Section Two: Understandings of Student Diversity and the Interrelationship Between
Student’s Sociocultural Background and Science Education ...................................................... 72
5.2.1 Elementary Educators Perspectives on Teaching Science to Diverse Students ........... 73
5.2.2 Elementary Educators Understanding of Official Discourses on Student Diversity
and Science Education .................................................................................................................. 90

Chapter Six: Obstacles in Teaching Elementary School Science ........................................... 102
6.1 Teacher Accountability and Science Education .................................................................. 101
6.2 Training and Support for Elementary Science Educators .................................................. 111

Chapter Seven: Conclusion ........................................................................................................... 118
7.1. Emerging Themes .................................................................................................................. 117
7.2 Key Issues ............................................................................................................................... 119
7.3 Conceptual Framework Considerations and Reflections ..................................................... 121

References .................................................................................................................................... 123

Appendices .................................................................................................................................... 138
Chapter One: Introduction to the Study

Deconstructing the complex sociocultural dynamics in educational systems and school culture is necessary to understand student diversity issues in school spaces. In Ontario, current educational reform policies have centered on the notions of equity and inclusion and the socio-transformation of school models (Ontario Ministry of Education, 2009a), as means to account for students’ diverse backgrounds. Educators play a significant role in the construction of students various literacies, as such, critical examination and reflection of pedagogical practices utilized by educators becomes increasingly important in socio-culturally pluralistic school environments.

I have worked for the past six years in a highly diverse school setting as a middle school science teacher. As a result, I recognize the importance of critically examining and reflecting on current pedagogical practices used in school science spaces to develop the scientific literacy for diverse learners. Science education is a sociocultural construct (Aikenhead & Elliott, 2010; Aikenhead 2006; Carter, 2008; Lemke, 2001). It is a system of complex, and often conflicting epistemologies and pedagogical practices concerning what constitutes school scientific knowledge and how students develop scientific literacy.

The National Committee on Science Education Standards and Assessment and National Research Council (1996) defines scientific literacy as “the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity…” (p.22). However, due to changing demographics in Western School culture, such as the increase in student diversity, there is a need for science educational discourse to examine sociocultural perspectives of scientific literacy development (Brown, 2004; Cuevas, Lee, Hart, & Deaktor, 2005; Hodson, 2003; Lee, 2002a; Lee, 2003; Lee and Buxton, 2010; Lee, Luykx, Buxton, & Shaver, 2007; Lee & Songer, 2003).
Specifically, the need to construct new ways of school science is based on research that continues to show there exists science achievement gaps between Whites/mainstream students and non-Whites/non-mainstream students (Lee, 2005a & 2005b; Orion, 2007).

In recent years, science educational reform policies have centered on addressing students’ sociocultural background (e.g., race, ethnicity, culture, language, class) in scientific school educational practices/processes (Ontario Ministry of Education, 2007). Scholars propose that school science systems must ensure that all students are engaging in meaningful/relevant scientific literacy development, reflective of students’ lived experiences/realities (Aikenhead, 2006; Calabrese-Barton, 2001a; Hodson, 2002a; Gitari, 2009; King & Ritchie, 2012; Norman, Ault, Bentz, & Meskimen, 2001; Rodriguez, 1998; Roth & Calabrese-Barton, 2004; Tobin, Roth, & Zimmermann, 2001). As a result, equity and or inclusion issues in science educational systems need to be addressed (Lee & Buxton, 2010; Lynch, 2000).

Over the past several decades, science educational research has focused primarily on deconstructing the scientific pedagogical practices and epistemological views of science educators, in particular elementary science educators. Research shows that elementary science educators’ Pedagogical Content Knowledge (PCK) (Abell & Roth, 1992; Akerson & Roth, 1999; Appleton, 2006; Cochran, 1995; Hodson, 2002a) and attitudes and beliefs about science educational processes (i.e. teaching and learning) (Jones & Carter, 2007) have implications for students’ scientific literacy development. However, in the context of increasing student diversity, scholars claim that there is a limited amount of research that focuses on elementary educators’ understanding of sociocultural models of science education (Jones & Carter, 2007; Bryan & Atwater, 2002; Chinn, 2012). This research is considered to be important as it can provide critical insight into how educational systems can effectively implement equitable and
inclusive based school science models that ensure the scientific achievement for all students, in particular socio-culturally diverse students.

1.1 Statement of Purpose and Research Question

This thesis presents elementary science educators’ perspectives on teaching science to socio-culturally diverse or minoritized students’ in the context of an equity and inclusive science educational model. The following question guided my study: how do elementary science educators conceptualize the intersection and interrelationship between science literacy and students’ sociocultural diversity? To answer my research question, I conducted semi-structured interviews with elementary science educators and critically analyzed Ontario Ministry of Education documents (e.g., policies and curriculum), on issues of equity, inclusion, and or, student diversity.

The overall objective of my study was to dispel preconceived notions/myths that elementary science educators are unable to critically reflect or interrogate their positions as science educators as means to address issues of student diversity and equity and inclusion in science education. Moreover, I wanted to uncover some of the complexities/challenges of addressing equity, inclusion, and student diversity issues in school science spaces.

The elementary educators understandings of the sociocultural contexts of science education is explored to show how educators play a significant role in shaping the scientific literacy of diverse and minority students, which has implications for these students scientific educational trajectories (e.g., high school, undergraduate studies).

As a result, the benefits of this study are to provide opportunities for key educational stakeholders (i.e., teachers, administrators, ministry) to reflect on their role in creating equitable
and inclusive educational models for diverse students, in terms of the processes/practices (i.e. teaching and learning) utilized in highly sociocultural diverse schools spaces. Moreover, this study highlights the need for future academic research on elementary science education in the context of student diversity and school curriculum.

1.2 Overview of Research Study

The rest of my thesis is divided into the following sections: Chapter Two provides an overview of scholarly works on student diversity issues in official discourses (e.g., policies) and elementary science educational discourse. Overall, the literature review examines theoretical/epistemological understandings of the sociocultural contexts of science education and affects on minority students’ scientific literacy development. In addition, critical pedagogy and antiracism are presented as conceptual frameworks for my research study.

Chapter Three describes the qualitative research study, in terms of the sampling criteria used to select study participants, data collection methods (i.e., semi-structured interviews and document analysis) and explanation of the data analysis process. Also, ethical considerations are noted in the section.

Chapter Four contains the document analysis of the Ontario Ministry of Education policy documents (2009a; 2009b; 2009c) on equity, inclusion, and or, student diversity and the science and technology curriculum document (2007). There are several key ideas presented in these policy documents, such as the role of school personnel (i.e., school boards, educators) implementing equity and inclusive based principles in all areas of the school culture. The analysis of these documents allow for a greater understanding of official discourses on student
diversity issues and effect on elementary educators understanding of student sociocultural diversity and science education issues.

Chapter Five begins with the participant profiles where I introduce the eight elementary educators selected to participate in the study. Specifically, I outline each participant’s personal and professional background and identify the types of diverse learners found in their science school spaces. The participant study profiles are followed up with a critical analysis of elementary educators knowledge of student diversity issues in science. I examine the participants understanding of school scientific literacy, students sociocultural diversity and scientific literacy development, and official discourses on student diversity and science education.

In Chapter Six, I explore obstacles in teaching elementary school science, with a focus on teacher accountability, science programming, and professional development issues, in the area of student diversity and elementary science education.

In Chapter Seven, I conclude my thesis by highlighting the key findings of my analysis and cite possible areas for future research in the areas of sociocultural student diversity issues and science education.
Chapter Two: Literature Review

The following literature review is divided into four major themes: (1) context of diversity policies in Ontario schools and science education; (2) elementary educators and science education; (3) science education models; and (4) access to science. In addition, I include a section on the conceptual frameworks used in my research study, critical pedagogy and antiracism.

2.1 Context of Diversity Policies in Ontario Schools and Science Education

The Greater Toronto Area (GTA) has the highest population of visible minorities in Canada (Statistics Canada, 2008). According to the 2006 Canadian census, over half of Canada’s visible minorities live in Ontario, where these individuals comprise 22.8% of Ontario’s total population. In addition, approximately 2.2 million visible minorities live in the Toronto, Metropolitan area, which is 42.9% of Toronto's population of 5.1 million. Educational scholars state that the increase in the racial diversity of Ontario student populations is a result of increase in Canadian immigration (Eggerston, 2006). As a result, the Canadian public education system must account for the large population of visible minorities in metropolitan areas/cities, such as Toronto (The Learning Partnership, 2007). Over the past couple of decades, official educational discourses have addressed student diversity in educational policies. However, scholars argue that official discourses on diversity and differences have not addressed how school systems can effectively implement inclusive and equity school models (Gérin-Lajoie, 2008; Jones, 2000). Moreover, the lack of collective action/effort amongst educational stakeholders (e.g., state, Boards, schools, students, educators, administrators, parents, communities) has resulted in a
variety of different approaches, interpretations, and models for addressing student diversity (Gérin-Lajoie, 2008).

A critical analysis of the historical and sociopolitical background of official discourses on diversity and differences reveals the complexities and challenges of implementing an inclusive and equity school model in mainstream schools. Harper (1997) examines the historical response to difference and diversity in Ontario schools. She argues that understanding historical responses is necessary for progressively [re]conceptualizing issues of diversity in schools. Specifically, she identifies five historical responses: (1) suppressing difference, based on the notion of cultural assimilation where education is based solely on Anglo-Saxon and Western culture/identity; (2) insisting on difference, based on the idea that differences amongst students are predetermined and natural and through the process of separation and segregation students’ differences can be accommodated; (3) denying difference, based on the notion of equal treatment for all in education by minimizing or ignoring student differences; (4) inviting difference, based on the notion of multiculturalism where schools celebrate and invite student diversity in school practices/processes; (5) critiquing difference, based on antiracist framework to interrogate power and identity structures in education in order to examine how schools and educational policies create inequalities amongst students. In Canada, there is no national/federal educational system. Education being under provincial and territorial jurisdiction, it is the responsibility of provinces and territories to create educational policies that address the needs of students and society (Ghosh & Abdi, 2004; Hodson, 1993 & 2001).

In 1971, the Canadian federal government established an official multiculturalism policy that addressed issues of equality amongst multiethnic groups in Canada. Even though, the policy upheld Canada as a bilingual (i.e. English and French) country, the policy established that there
is no official/dominant culture within the country (Gérin-Lajoie, 2008). In the context of education, the multiculturalism policy has affected the epistemological framework/models in educational institutions. According to Joshee & Johnson (2007) recognition of cultural dynamics and cultural diversity in educational institutions became important in provinces such as Ontario and British Columbia. Since the 1970s the multicultural educational model has been utilized as a dominant educational model (Gérin-Lajoie, 2008). Banks & McGee Banks (2010) defines multicultural education as:

Multicultural education is at least three things: an idea or concept, an educational reform movement, and process. Multicultural education incorporates the idea that all students—regardless of their gender, social class, and ethnic, racial, or cultural characteristics—should have an equal opportunity to learn in school. (p.3).

Additionally, Banks & Banks (1995) states that there are five major dimensions to multicultural education: (1) content integration, which refers to educators actively using culturally relevant materials (e.g., information, examples) in all school subject disciplines; (2) knowledge construction, which identifies cultural assumptions and or biases inherent in knowledge systems; (3) prejudice reduction, which relates to the idea of ensuring students develop democratic attitudes and values; (4) an equity pedagogy that adopts practices that ensure the academic success of sociocultural diverse students; and (5) an empowering school culture and social structure which refers to systematically transforming school spaces to ensure that all students meet with academic success. Overall, the objective of a multicultural educational model is to ensure equality amongst minority and majority students, in terms of academic achievement. And it is the primary responsibility of educators to ensure that they provide equitable learning and teaching environments that reflect the needs of socio-culturally diverse students.

The multicultural educational approach reflects the multiculturalism policy of 1971 as the approach attempts to systematically reform/transform schools to be reflective of the sociocultural
diversity in Canadian society. Hence, in the Canadian federal government passed the Canadian Multiculturalism Act—Bill C-93 into legislation, which recognized cultural diversity as an integral part of Canadian society (Dewing, 2009). Ministries of Education throughout the country had already begun to address diversity and difference in schools. However, several scholars argue that the multicultural educational model does not effectively address the systematic oppression/inequalities and inequitable power relations that exist in Western school systems (James, 2001; Kirova, 2008). Moreover, Joshee & Johnson (2007) contend that diversity initiatives are not necessarily a major issue in the Canadian political agenda.

In the Ontario political context, over the past several decades, Ontario provincial governments (i.e., Conservative, Liberal, or New Democratic Party) have had different political agendas for education. For instance, in 1993, the NDP developed policy guidelines on equity, such as the “Antiracism and Ethnocultural Equity in School Boards: Guidelines for Policy Development and Implementation”, which required Ontario school boards to develop and implement antiracism and ethnocultural equity policies in schooling processes/practices. However, in the mid 1990s the Harris Conservative government took power and they did not request the implementation of the policy. It stayed on the shelf (Gérin-Lajoie, 2008). It has only been in recent years that the Liberal government has produced educational policies on equitable and inclusive education. Specifically, the Ontario Ministry of Education has developed the following policy documents, “Realizing the Promise of Diversity, Ontario’s Equity and Education Strategy” (2009a), Policy/Program Memorandum No.119: Developing and implementing equity and inclusive education policies in Ontario schools (2009b), and the “Equity and Inclusive Education in Ontario Schools: Guidelines for Policy Development and Implementation” (2009c). The aforementioned policy documents provide guidelines for school
boards on how to implement equity and inclusion in school systems. One of the key areas in the Liberal document is reforming school curriculum to incorporate equity and inclusive based principles. Nonetheless, educational reform policies on diversity are only effective if the government facilitates the implementation and monitoring of these policies.

In the context of science education, provinces or territories are responsible for constructing school scientific literacy (i.e., school science curricula) (Canadian Council Ministers of Education, Canada, 1997). In 1997, the CMEC developed the document, “Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum” which outlines the Council’s perspectives on science literacy and education in Canada. However, according to Aikenhead (2006), the aforementioned document constructs school science in a Western/Euro-Canadian cultural framework, which marginalizes minority students (e.g. Aboriginals) and other ways of knowing science (e.g. Indigenous knowledge). In early December 2007, Statistics Canada (2006) published the latest results of the Programme for International Student Assessment (PISA) on scientific literacy. Overall, results show that Canadian 15 year-olds students performed very well in science as compared to other OECD (The Organization for Economic Co-operation and Development) countries. However, across the provinces and territories there are differences in the science performance of immigrant and non-immigrant youth. The results of the study are as follows: (1) non-immigrant youth outperformed first generation peers, in particular in the provinces of Ontario, Manitoba, and Quebec; (2) non-immigrant students outperformed second-generation immigrant youth who were born and educated in Canada; (3) overall, in Ontario, second-generation immigrant students outperformed first-generation immigrant students (Statistics Canada, 2006). Even though, the aforementioned findings show that Canadian students are performing well in science, differences still exist in
scientific achievement amongst Canadian students, which can be linked to a number of characteristics. One of the key characteristics is student diversity. As a result, various provinces have officially addressed student diversity in school science curriculum documents. For example, in Ontario, the Ministry of Education (2007) has revised the science curriculum to address the sociocultural diversity of students in program planning, such as the “Antidiscrimination Education in the Science and Technology Program” (p.36). The overall objective is to create school science programs that acknowledge sociocultural diversity by using equity and inclusive science pedagogical practices to develop students’ scientific literacy. Lemke (2001) highlights the following as key areas of sociocultural research in science education: (1) classroom discourse, (2) language and science education, (3) minorities in science education, (4) gender equity and (5) language-minority students issues. However, one of the major sociocultural issues in science education is the “cultural conflict between the normative culture of science and the community cultures” (p.302). Western school science is highly Eurocentric in nature, as such the underrepresentation and/or exclusion of cultural diversity in scientific learning processes/practices positions minorities at a ‘scientific educational disadvantage’. Hence, current research efforts should, in addition to Lemke’s themes, focus on developing inclusive-based pedagogical models for teaching science, such as multicultural, cross-cultural, traditional/indigenous, anti-racist, and urban science educational paradigms to address issues of minority students’ science learning. Overall, the underlying objective of these pedagogical frameworks is to provide students with alternate forms of science learning that positions students and their experiences at the center of classroom spaces. The aforementioned areas of sociocultural research in science education are discussed in detail in the third theme of the literature review, scientific literacy and student diversity.
2.2 Elementary Educators and Science Education

In scientific educational discourse, there is a considerable amount of research on educators’ knowledge of teaching science. Fischer, Borowski, & Tepner (2012) categorize research on the professional knowledge of science teachers into three areas: (1) content knowledge; (2) pedagogical content knowledge; and (3) pedagogical knowledge. However, in elementary school science educational discourse, pedagogical content knowledge (PCK) has been the topic of many studies, in particular the nature and development of PCK. Cochran (1997) states the following:

Pedagogical content knowledge is a type of knowledge that is unique to teachers, and is based on the manner in which teachers relate their pedagogical knowledge (what they know about teaching) to their subject matter knowledge (what they know about what they teach). It is the integration or the synthesis of teachers’ pedagogical knowledge and their subject matter knowledge that comprises pedagogical content knowledge. (p.14).

The concept of PCK is significant because science educators have different pedagogical perspectives/experiences about teaching and learning science, which has implications for students’ scientific literacy development. For example, Appleton (2006) suggests that elementary educator’s PCK is based on “activities that work” (p.37) and are not necessarily concrete/realistic scientific pedagogical practice. Further, several scholars claim that elementary school teachers’ science PCK development is affected by several factors such as, teacher confidence (Abell & Roth, 1992), content knowledge (Appleton, 2006) and pedagogical knowledge/strategies (Hodson, 2002b; Van Driel, Beijaard, & Verloop, 2001). Barnett & Hodson, (2001) suggest an elementary science educator should adopt four kinds of knowledge to effectively build students scientific literacy: academic and research knowledge, pedagogical content knowledge, professional knowledge, and classroom knowledge. Overall, according to Appleton (2006), some form of science PCK is necessary in order to effectively teach science. As a result, there is a
considerable amount of science educational research on pre-service and in-service elementary science teacher education programs in the areas of: (1) science PCK development (Loughran, Mulhall, & Berry, 2008; Mulholland & Wallace, 2005); (2) professional development and teaching strategies (Levitt, 2002; Shapiro, 2006); and (3) elementary science teacher mentoring (Hudson, 2005; Jarvis, McKeon, Coates, & Vause, 2001).

Comparatively, Chinn (2012) argues for an increase in educational research on teacher education programs for developing “place-based and culture-based PCK”. She states, “science teachers and students differ significantly in language, culture, and values, place-based programs incorporate an explicitly culture-based perspective in order to situate teachers’ learning in meaningful contexts focused on underrepresented learners’ knowledge and experiences” (p.328). Science educators must socio-culturally contextualize science PCK in order to effectively develop teaching strategies that meet the needs of diverse students/communities. However, according to Chinn there are only a few teacher education institutions that regularly address place-based and culture-based science education courses, which arguably does not allow for meaningful and relevant science PCK development.

Furthermore, educational practitioners play a significant role in the construction of the students’ scientific literacy development. Several research studies show that science educators’ attitudes and beliefs towards science teaching and learning represent a critical influence on student scientific literacy development (Earl & Winkeljohn, 1977, Bryan & Atwater, 2002; Hashweh, 1996). Specifically, scholars claim that science educators may unconsciously and consciously reinforce scientific stereotypes because conclusions about science are often determined by the educator. Notwithstanding that, governments regulate the science curriculum, its implementation in the classroom is carried out by teachers.
But elementary (K-6) teachers are not required to be curriculum ‘experts’ or ‘specialists’ in the particular school discipline in order to teach it. As such, this provides spaces for stereotypes and negative messages/attitudes to be constructed that impact the quality of science learning in classroom spaces (Jones & Carter, 2007). Assumptions that teachers have practical knowledge of science teaching and therefore can ‘accurately’ teach any subjects are questionable. Indeed, research studies show that elementary science teachers use inadequate scientific instructional practices, such as textbooks to instruct children in science, which has implications for students’ interest in science (Yager, 1983). In the classroom a teacher’s voice creates the science classroom culture where students may assume that the voice is truth. Consequently, images and ideologies represented in the voice can contain scientific positivist/traditionalist ideas and stereotypes that do not reflect the reality of students’ lived experiences or understandings of science. In addition, teachers have the power to choose educational practices, resources and epistemologies that may reflect personal or state values. As a result, a student’s scientific literacy can be affected by these values.

The other ways that educators affect students’ perceptions about science are through the construction of the students’ scientific literacy. For instance, certain pedagogical practices within science classrooms can conflict with students from certain cultural groups’, which make it difficult for these students to meet Western expectations. Hodson (1993) observes “within the classroom there can be all kinds of negative messages conveyed to particular ethnic groups by teachers’ remarks and actions” (p.693). Some scholars claim that it is the underrepresentation of ethnic minority teachers in science education that affects the scientific experiences of students. Ryan, Pollock, & Antonelli (2009) compared the racial diversity of Canadian secondary and elementary teachers from the 2001 and 2006 Census data with the diversity of the student and
general populations. The results of the study show the following trends: (1) the proportion of visible minority teachers in the overall teacher workforce is less than the proportion of visible minority citizens in the general Canadian population; (2) the proportion of visible minority teachers in the teacher workforce has decreased relative to the proportion of visible minority citizens in the Canadian population, although their actual number has increased; (3) racialized teachers tend to work in large cities. Moreover, the scholars cite in 2006 the percentage of visible minority teachers compared to the percentage of total visible minority population in Ontario was 9.5% and 22.8% respectively. Comparatively, in Toronto the percentages were 18.6 and 42.4% respectively. Overall, there exists a gap between the proportion of Canadian educators and racial diverse students.

It is extremely important that teachers reflect the cultural makeup of schools in order to enhance cultural compatibility in student-teacher relationships, critically deconstruct curricula biases, develop positive attitudes toward individuals and ‘culturally’ connect with students of varying backgrounds. Moreover, scholars contend that science educators should use culturally relevant teaching practices to address student diversity (Ladson-Billings, 1995; Nelson-Barber & Estrin, 1995). Barba (1993) argue that role models are important for developing positive science attitudes in students, particularly, in minority students. Arguably, White teachers are capable of providing antiracist educational experiences for ethnic minority students; however, it is the presence of racial minority teachers that legitimizes the educational system as being representative of all students.

It cannot be assumed that racial minority teachers are ‘experts’ in antiracist and inclusive educational practices that positively impact minority students. Typecasting racial minority teachers as experts is problematic because many of these teachers have dominant cultural capital
that does not reflect the capital of minority students (Carr & Klassen, 1996). In addition, it
cannot be assumed that racial minority teachers create more effective learning environments for
students (Villegas & Davis, 2007). Overall, all teachers must be critical, and constantly evaluate
learning spaces and apply educational criticism to teaching practices (Sleeter, 2004). Otherwise,
students are at a disservice. Furthermore, science educators must actively and critically examine
the social, cultural and political contexts of science education in order to identify and remove
biases within the discipline. This would present students with authentic/realistic portrayals of
science. Although, awareness of scientific stereotypes does not guarantee the modification of an
educator’s attitude towards the discipline, critical pedagogical practices allow educators to
examine issues of power in teaching and learning contexts as a means for change.

2.3 Science Education Models

Science educational discourse shows that there are several epistemological models of
science, such as universal, multicultural, critical multicultural science, antiracism science, urban
science, traditional ecological knowledge and indigenous knowledge, etc. However, one of the
most dominant and controversial scientific epistemological debates is between universal science
education and multicultural science education.

2.3.1 Universalism

Schools have primarily adopted a Western modern science (WMS) educational paradigm
that is grounded in the philosophy of universalism. Lee & Buxton (2010) state the following:

Universalist science is the view that because the natural world follows a
consistent set of rules, and because science is the quest to understand and explain
those rules, then science must be practiced in the same way no matter where or by
whom it is done. There is no place in universalist science for one’s race, ethnicity,
culture, language, gender, or other external factors to influence science practice.
(p.24)
Universalist science has implications for school science curriculum and students’ scientific identity development. Stanley and Brickhouse (2001) cite Harding’s work to show their criticisms of universal scientific approaches. Harding states “universalists argue that WMS provides a superior knowledge of the natural world as compared with pre-modern European thought or the various ‘folkthought’, ‘ethnosciences’, and other less worthy forms of knowledge held by non-Western cultures” (p.36). This suggests that it is not necessarily the philosophy of universalism that is controversial, but its superiority complex and resulting exclusion of other forms of scientific knowledge that is an issue. The notion of universalism is advocated by supporters of traditional/realist/positivist perspectives of science, which uphold science as a rational and objective discipline void of cultural influences. For example, Matthews (1994) believes WMS is an “intellectual activity whose truth-finding goal is not, in principle, affected by national, class, racial or other differences” (p.182). Matthews’ arguments are supported by Loving (1995), Southerland (2000), and Siegel (1997) who also adopt realist/universalist claims to argue the superiority of the WMS model in understanding the ‘natural world’ (i.e., sciences) and its dominance in educational spaces. However, Siegel (2002) strongly rejects claims that universalists adhere to “strong realist” notions of science. He contends that Universalists do recognize culture, but that culture does not influence science or notions of the ‘natural world’. Situated within this context, science becomes an entity, in itself, independent of any cultural relevance. Arguably, it was the legitimacy and hegemony of WMS by mainstream educational institutions that led to the systematic exclusion of alternative forms of science (e.g. multicultural, indigenous, anti-racist, etc.).

To the contrary, Cobern & Loving (2001) argue that the definition of science must be revised to include other forms of scientific knowledge. One of the major implications of a
dominant universalistic view of science is that it limits students’ scientific literacy and identity development. Reproduction of the WMS model legitimizes this type of school science knowledge as a truth/reality where other representations of scientific knowledge are excluded or marginalized within an educational context. However, according to Lee & Buxton (2010) other constructs of science knowledge (i.e., ethnosciences) have been recognized by WMS. Despite various epistemological views of science in the science education community, scientific universalism remains dominant in school science spaces. Consequently, students who may identify with different forms of science are unable to utilize their knowledge, skills and practices to support students’ ‘lived’ or personal understandings of science. Moreover, claims that culture is irrelevant to scientific knowledge presume that science is not a social, cultural, and political construct defined by majority individuals.

School science education reflects the states’ value of science (Hodson, 1993 & 1999). As a result, it is not necessarily the ‘reality of the natural world’ that needs to be critically examined, but rather how WMS theories and practices about the ‘reality of the natural world’ are defined, and by whom (Rivera-Maulucci & Calabrese-Barton, 2005). In contrast, it can be argued that students need to acquire a Western-based science education in order to effectively participate in Western society (Williams, 1994). However, if this is the case, then educational systems must be held accountable for the achievement gaps between majority and minority students and should develop strategies to ensure that all students can effectively participate in science school subculture.

2.3.2 Multiculturalism

Over the past couple of decades, science education discourse on issues of student diversity and science education has focused primarily on multicultural science education models.
Multicultural science challenges notions of universal science by acknowledging science as a socio-culturally constructed discipline (Hodson, 1993; Buxton 2001a; Lee & Buxton, 2010; Siegel 2002; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). Atwater & Riley (1993) state the following about multicultural science: “[it is a] body of knowledge [that] includes our understandings of group identification, culture, and science. It relates to science learning and achievement, science instruction, and the involvement of different cultural groups in the sciences” (p.665). Proponents of multicultural science education argue that non-Western or indigenous science should be included in WMS (Chinn, 2007; McKinley, 2007; Ogunniyi, 2007a & 2007b; Riggs, 2005). Snively & Corsiglia (2001) state, “indigenous science relates to both the science knowledge of long-resident, usually oral culture peoples, as well as the science knowledge of all peoples who as participants in culture are affected by the worldview and relativist interests of their home communities” (p.6). Moreover, “indigenous science includes the knowledge of both indigenous ex-pansionist cultures (e.g., the Aztec, Mayan, and Mongolian Empires) as well as the home-based knowledge of long-term resident oral resident peoples (i.e., the Inuit, the Aboriginal people of Africa, the Americas, Asia, Australia, Europe, Micronesia, and New Zealand)” (p.10).

One of the major branches of indigenous science is Traditional Ecological Knowledge (TEK) or Indigenous Knowledge (IK). According to Usher (2000), “TEK refers specifically to all types of knowledge about the environment derived from the experience and traditions of a particular group of people” (p.185). TEK explores the relationship between living things and nature (or environment) from a cultural perspective, which allows for diverse cultural understandings of scientific knowledge. TEK is widely recognized by the scientific community because of its contribution to WMS, in particular in the areas of biology and ecology (Snively &
Corsiglia, 2001). However, in a science educational context, TEK is not officially recognized as a mainstream science educational model (Lee & Buxton, 2010; Snively & Corsiglia, 2001). Nonetheless, scholars argue that the increase in multiple views of science challenge dominant notions of scientific knowledge and highlight the need to address issues of equity in school science education.

One of the themes/concepts discussed in multicultural science educational discourse is the notion of cultural transition or border crossing (Aikenhead & Jegede, 1999; Jegede & Aikenhead, 1999). Several scholars view Western science as a sub-culture, that is, a cultural construct of Euro-American culture where non-mainstream students have to cross a “cultural border” (Jegede & Aikenhead, 1999) in order to access Western science culture. Aikenhead (1997) characterizes the concept of “border crossing” in the science classroom as a “cultural event” where students have to culturally assimilate in order to participate in the subculture of science and school science. Specifically, school science is a reproduction of the sub-culture of science – that is the dominant Euro-American scientific culture (Stanley & Brickhouse 1994). Consequently, if the dominant form of scientific knowledge in schools (i.e. curriculum) is constructed in a Western/Eurocentric context it places some students at an academic disadvantage because cultural barriers create access issues. However, for many racial/ethnic minority students, such as First Nations students, Western modern science (WMS) is seen as a process of “cultur[al] acquisition” (Aikenhead, 1997) – students have to assimilate, perform and reproduce knowledge and practices that may conflict with their own cultural understanding of science and/or realities. Jegede & Aikenhead (1999) states the following: “success in science courses depends on (1) the degree of cultural difference that pupils perceive between their life-world and their science classroom, (2) how effectively pupils move between their life-world
culture and the culture of science or school science, and (3) the assistance pupils receive in making those transitions easier” (p.8). As a result, scholars propose the need for developing culturally relevant science curriculum (Aikenhead 2001, Aikenhead & Jegede, 1999), in order to create equitable learning science opportunities for non-mainstream learners.

Critical multicultural science education is one of the most commonly discussed theoretical frameworks of multicultural science education. Critical multicultural science education differs from multicultural education because it examines the socio-political context (i.e. race, gender, class, etc.) of science education (Ahlquist & Kailin, 2005; Buxton, 2001b; Kailin, 2000). Fusco & Calabrese-Barton (2001) state the following:

[C]ritical science education, [is] an inclusive vision of science education which draws on the ideas raised by critical, feminist, and multicultural science educators. We use this critical science education perspective to raise questions about the nature of science and knowing in science, the relationship between science and society, and the implications these belief structures have for how we view science as a school subject. (p.338)

The overall argument is that multicultural education tends to focus primarily on culture, whereas critical multicultural science education examines the need for including the voices and experiences of minority groups (Lee & Buxton, 2010) in science educational processes/practices. Ahlquist and Kailin (2005) state that critical multicultural science education is about deconstructing school science curriculum in a socio-political context. As a result, students should use a critical lens to explore the effect of science and technology on society in order to actively participate and make meaningful connection to science culture (p.37). Moreover, anti-racist science education is characterized as a theoretical perspective/strand of critical multicultural science education that addresses issues of racism and other social oppressions (i.e., gender, ethnicity, religion, class) in science (Hodson, 1993; Hodson, 1999). McKinley, Waiti, & Bell (1992) state: “Anti-racist science education is described as being concerned primarily with
actively challenging institutional racism at all levels of science education and providing support and encouragement to students in recognizing and opposing racism in science themselves-racism that results in unequal distribution of wealth, resources and power” (p. 587). Science is not objective; it embodies sociocultural values and biases that become normalized within the science discourse. As a result, anti-racist science education attempts to deconstruct the racist ideologies inherent in educational institutions (i.e., Board, schools, teachers, etc.), which lead to the marginalization and lack of membership of minority students in school science communities. However, challenging racist notions in science education requires the educational system to identify power structures that create oppression and discrimination for some minority groups.

Despite, the various theoretical strands, science educational discourse shows that there is a need to transform science education and school science subculture to address the needs of diverse learners, in particular minority or marginalized groups. Overall, some underlying questions emerge from the research on universalist and multicultural science education. (1) Who determines what are real and legitimate forms of scientific knowledge? (2) Why are certain forms of knowledge legitimized by educational systems? (3) How do society and the state influence current science educational practices? The proposed questions guide my research study as I critically examine elementary science educators understanding of school scientific literacy and implications for diverse students science learning experiences.

2.4 Access to School Science

Why is it important to understand how students learn science? What are students learning in science classes? Who is experiencing difficulty, and or, not learning in the science classroom? Differences in scientific achievement among groups suggest that educational institutions have
failed to effectively address the diverse learning styles/processes of students. In educational institutions students are expected to acquire the culture, language, and discourse of the mainstream/dominant group. This expectation creates possibilities of access for students of diverse backgrounds. In this section of my literature review, I examine two major research areas on students’ access to science: (1) urban students and science education and (2) language and science education.

2.4.1 Urban Students and Science Education

In educational research discourse, there are various definitions of urban education. In summary, urban education refers to the schooling of minority (i.e. racial/ethnic minorities) students or students of low socioeconomic backgrounds in large metropolitan areas (i.e. inner-cities) (Adams & Adams, 2003; Alston, 2002). Over the past decade, science educational discourse has focused on teaching science in diverse settings, such as urban settings. Specifically, numerous journals, such as the Science Education, Journal of Research in Science Teaching and Research in Science Education have published articles on, or related to urban students and science education. Calabrese-Barton (2007) defines urban science education as the “stud[y] of the intersections among students, their families and their teachers, science, schooling, and the historical, physical, environmental, social, economic, and political aspects of urban life” (p.321). She identifies three key themes in research studies on urban science education: (1) there is a scientific achievement gap amongst urban and suburban students, in particular White students and minorities; (2) students’ sociocultural status plays a role in the existing achievement gap; (3) the achievement gap is due to inadequate educational funding and limited resources in urban schools.

Moreover, scholars claim that urban students are experiencing ‘scientific educational
failure’ because mainstream school science culture and discourse does not necessarily reflect the lived realities of these students (Calabrese-Barton, 2001a; Calabrese-Barton, Ermer, Burkett, & Osborne, 2003; Emdin, 2012; Varelas, Kane, Tucker-Raymond & Pappas, 2012). Specifically, Tobin, Seiler, & Walls, (1999) states that students in urban ‘centers’ are subjected to issues of poverty, where there is a lack of appropriate educational resources, highly qualified teachers, laboratory equipment, participation in school-science activities, and inadequate funding. Consequently, science education is not perceived as a priority, which positions these students at a scientific educational disadvantage.

Scholars argue that urban students must be given opportunities to construct meaningful science learning experiences by making science reflective of their lives. Burkett, Calabrese-Barton & Louis (2001) argue the need to adopt an “emergent science” approach when teaching urban students. Emergent science refers to students “life-worlds”. Specifically, “it is science that emerges from the intersection of the interests, values, experiences, and beliefs of student and their life-worlds” (p.80). For example, in urban science education there is a focus on the notion of “connected science” – which Bouillon and Gomez (2001) define as the process of bridging both school science and science of outside communities (i.e., home). Constructions of science from a real-world context/framework allows students to self-identify with science learning which in turn allows for science identity development. Furthermore, the idea of self-identifying with science is important because some minority students may feel like mainstream school science is not representative of their identities thereby resulting in feelings of not belonging or a lack of legitimate participation in science education. This argument suggests that science learning is a process where students have to personally invest in the process in order for the science learning to be transformative, that is, a part of their lived experience. Consequently, developing science
programs that do not speak to minority students’ identities results in science achievement gaps and different science outcomes amongst groups.

Urban science education is an effective paradigm because it teaches students (regardless of racial/ethnic, cultural, socioeconomic, linguistic differences) the power of resistance and attempts to eradicate dominating school power structures by giving students the power to construct meanings of science within their own context. For example, Fusco (2001) reports that students tend to engage actively in informal science experiences, such as nonschool- and non-curriculum-based interaction with science in environments (e.g., science centers, museums, zoos, parks, and nature centers) because these experiences are considered fun and more relevant to their future. As a result, meaningful science learning takes place if students are given the opportunity to critically question and deconstruct the scientific knowledge and practices that they are experiencing.

Urban science education highlights the need for the interconnection between social justice and science education. Calabrese-Barton (2001b) cites Peter McLaren who views the intersection between critical pedagogy and production of scientific knowledge as teachers “critically assessing the science and how it may intersect with the lives of students...[and] also critically assessing why it is that conversations about power and authority—at both local and global levels—are generally not allowed in science class” (p.854). A social justice approach to science education allows for “transformative scientific education” because the social and cultural context of the students situated in the science learning and teaching practices (Atwater & Suriel, 2010).

The science educational experiences of inner-city youth are different from those students living in suburban/affluent communities. As a result, science learning should be constructed
differently according to the needs, identities, and or experiences of the students in diverse school spaces. Also, students should use a critical scientific approach to learn about science and technology, in order to understand how science and technology affects individuals and society. Rivera-Maulucci and Calabrese-Barton (2005) state the following about critical science education: “[it] encourages students to see themselves as agents of change in their lives and community” (p.109). Overall, science education is a “political activit[y]” (p.108) where students have to be active in constructing their own science identities. For example, Reiss (2003) focuses on how students can use school science education to promote social justice outside of academic institutions. His argument is that students should be able to apply school scientific knowledge to afford positive change within their society by adopting a ‘civic science identity’.

Hildebrand (1999) discusses the need to interrogate/deconstruct existing essentialized science learning models as means to ensure the models overall effectiveness. Also, the importance of creating new science educational models for students, such as “critical activism” – the science learner actively engages in critical analysis and reflective criticism of scientific discourses to make sense of the knowledge. Overall, by adopting a social justice approach to scientific literacy, as described by Hildebrand (1999), it is the students that take control/power of the learning because it is the student that is making sense of the learning in their own personal context.

2.4.2 Language and Science Education

Linguistic diversity continues to be a major theme in educational discourse as Western societies continue to become increasingly culturally pluralistic. Key highlights of a Statistics Canada (2011) report on the linguistic characteristics of Canadians show that: (1) there are more than two hundred home or mother languages in Canada; (2) one-fifth of the Canadian population
speak a non-official language at home or in combination with English or French; (3) eighty percent of the population who reported speaking an immigrant language (i.e., a language other than English, French or an Aboriginal language) live in one of Canada's six largest census metropolitan areas. It should be noted that Toronto has the largest proportion, 32.3%. Overall the report calls attention to the fact that the majority of Canadians are using multiple languages (i.e., immigrant languages) at home. In the context of education, the linguistic diversity of students can create barriers for accessing school curricula, especially when English is the dominant language in mainstream school spaces.

Over the past decades, several science educational research studies have addressed the complex nature of scientific language (e.g. specialist terminology/concepts, reading and writing practices) and its effect on teaching and learning science in educational institutions. Scholars report that difficulties with scientific language acquisition in schools are not mutually exclusive to non-speaking English learners but include native speakers of English (Gardner, 1974; White, 1988). Muralidhar (1991) discusses the complexity of scientific language in the context of the science learner as follows:

> the pupil has to cope with: his or her own language while writing notes or completing homework; teacher's spoken language; the language used in curriculum materials and textbooks; teacher's written language on the chalkboard, handouts and tests; the terminology of science; and the disparity between the meanings of the same words when used in everyday language and when used in the context of a science lesson. (p.253)

Muralidhar (1991) describes some of the linguistic challenges experienced by students in science classrooms to show how language is an integral component of students’ scientific literacy development. Therefore, deconstructing the complexity in scientific language processes/practices (as outlined in school curricula) and the resulting linguistic barriers will
provide a better understanding of some of the ‘linguistic inequities’ experienced by students in science classrooms.

School science knowledge reflects the language practices and the cultural capital of the dominant groups in society. Bourdieu’s concept of cultural capital refers to the “notion that culture may represent a source of status or power” (Ritzer, 2005, p.168). Furthermore, if dominant status groups are able to legitimize their cultural form in society they can reproduce cultural hierarchies. Arguably, these cultural hierarchies contribute to the exclusion of other forms of social practices/knowledge/experiences that may support students learning processes.

In the context of science, students who are not members of the dominant culture are at an educational disadvantage because they do not have the cultural capital to equitably participate in Western science. Pierre Bourdieu (1999) in his discussion of inheritance contends that there is a direct correlation between an individual’s sociocultural capital and educational trajectory. Transmission of inheritance depends on the schooling system, which favours individuals’ of social privilege (i.e. the dominant class). Consequently, the majority of students inherit capital that allows them to actively participate in educational systems because they acquired the ‘right’ capital (i.e., class, language, racial/ethnicity, gender, sexual orientation). On the other hand, others must assimilate and acquire the capital to participate in these mainstream spaces. All forms of mainstream educational discourse are reproductions of societal discourse where structures of oppression (e.g., language and culture barriers/inequities) exist in all mainstream schools that systematically disadvantages minority students. As a result, the type of capital that students bring to schools is important to document for understanding how educational institutions can support students’ diverse needs.
Moreover, the concept of cultural capital can be used to explain differential academic achievement between students and, understanding the relationship between culture and achievement. In the context of school science and language-based practices, research shows a disconnect between minority students’ primary/home and community experiences (e.g., cultural values, language) and the traditional approaches (i.e. WMS) to science-related disciplines in schools (Atwater, 1994; Cobern & Aikenhead, 1998). Lee (2003) cites research studies on the issues of scientific inquiry and theory based learning as a challenge for minority students because it requires them to assimilate in order to access school science discourse. She states, “discontinuities between cultural expectations and scientific practices require [diverse] students to shift between different types of knowledge, practices, and discourse if they are to have access to school science without abandoning their home culture” (p.466). Consequently, if students are unable to access the scientific language practices in schools because of linguistic barriers, it can result in limited participation and challenges in learning science. According to the official discourse on scientific language in schools as cited by Lee (2003), students should be given opportunities to use their cultural identity to learn the “high-status knowledge of mainstream schools science” (p.467). However, the notion that science is a “high-status knowledge” is controversial in itself because it creates and reinforces power imbalances between those students who have dominant cultural capital, in which the scientific knowledge is constructed from, and those who do not. Arguably, scientific language is not “neutral” (Sutton, 1992) because it is constructed from a social, cultural, historical and political context, which reflects those in power who legitimize dominant forms of scientific knowledge in political spaces, such as educational institutions. Minority students are expected to assimilate in order to actively participate in the subculture of science (Aikenhead & Jegede, 1999; Hodson, 1993 & 2001). This assimilation
includes acquiring dominant ‘scientific linguistic capital’ reproduced within schools. As result, it requires educational practitioners to address language issues in science; however, it cannot be assumed teachers are ‘experts’ and therefore able to effectively address the diverse linguistic and cultural identities of students.

There are three major areas of concern when examining the access to science for non-English speaking learners: (1) curriculum resources (Barba, 1993; Hampton & Rodriguez, 2001); (2) instructional practices (Lee, et al., 2004; Lee, et al., 2007); and (3) assessment (Abedi, 2004; Abedi, Hofstetter & Lord, 2004; Fradd & Lee, 1999; Solano-Flores & Trumbull, 2003).

First, as previously discussed, curricular emphasis on the acquisition of the language of science is challenging for students with limited English language skills. Hodson (1993) notes that “the terminology of science, specialized usage of common words and formalized language can lead to withdrawal and limited participation by non-proficient English learners” (p.691). This is because students from diverse cultural backgrounds have ways of communicating that are different from the mainstream. However, allowing students to use their multi-linguistic experiences within the science classroom can be a valuable resource for enabling these students to find meaning in science (Hodson, 1993; Rakow & Bermudez, 1993). An inequitable learning environment is created if students who do not have the ‘linguistic’ capital are not allowed to use their linguistic identities to access school content. Similarly, science curricular resources (e.g., textbooks) must be culturally and linguistically appropriate for English language learners (Hampton & Rodriguez, 2001).

Second, the dominant perception of effective scientific instruction as engaging students in scientific inquiry-based activities can prove to be challenging for students from a non-English language background (Lee, Hart, Cuevas, & Enders, 2004; Lee, Buxton, Lewis, & LeRoy, 2006).
Primary English-speaking students are at an educational advantage in science classrooms because they already have the prior knowledge and background (social and cultural conditioning) to engage in scientific inquiry activities (Hodson, 1993). School science is reflective of Western society where mainstream students are familiar with the ‘values of science’ and linguistic minority students do not necessarily have the same experiences. As a result, the scientific instruction of language minority students would have to be structurally different as a means to promote meaningful science learning.

Last, traditional methods used to assess scientific learning do not effectively show the scientific understanding of all English language learners (Siegel, 2007). For example, in the majority of science classes, students have to demonstrate their scientific literacy through formal lab writing. However, a language learner student that speaks English as a second language will experience difficulty carrying out these tasks. As a result, alternative assessment strategies (e.g., oral and drawing accounts) are needed to support these students.

2.5 Conceptual Framework

In this section, I discuss frameworks that informed my research study: critical pedagogy and antiracism. Specifically, I highlight the works of several scholars that have contributed to the aforementioned frameworks with a specific focus on teacher education. Also, I discuss how these theories are relevant to my research study.

Critical pedagogy is an alternative form of schooling or political pedagogy that resists oppressive social hegemonic/mainstream educational discourses by examining the interrelationship between power, ideology, and knowledge in educational sites (Apple, 1995; Bartolomé, 2004; Giroux, 2004; Kincheloe, 2004; Leistyna, Lavadenz, & Nelson, 2004). Critical
pedagogy has developed from several theoretical disciplines including Marxism, critical theory, feminism, post-colonialism, post-structuralism, media studies, cultural studies, anti-racist studies and postmodernism (Leistyna, et al., 2004). One of the key theoretical concepts of critical pedagogy is the notion of critical consciousness/conscientization (conscientização) developed by critical educational theorist and political activist Paulo Freire. Most notable is his critique of the educational system in “The Pedagogy of the Oppressed” in which he describes the teacher-student relationship as the banking concept of education. Freire uses the “banking” concept to describe how teachers systematically monopolize power over students by controlling the transfer of knowledge. As a result, students are objects where their passivity to social realities inhibits the development of a critical consciousness required to actively participate in the social transformation of school and society. Consequently, Freire proposed the problem-posing method in which students acquire critical consciousness and are proactive in their education as a solution to the ‘banking system’ of education. The problem-posing method is governed by the principle that dialogue is key, and if mutual communication between teacher and student is present, it allows students to become critical thinkers characteristics required for an individual to be human.

Several research studies have proposed that critical pedagogy is an effective democratic educational model for addressing the social inequities that exist within educational sites. In 2004, the Teacher Education Quarterly journal published a series of articles that focused on critical social theory and teachers, and teacher education programs. These articles view educators as the central agents of socio-political change in educational spaces. Educators have the power to revolutionize their pedagogical practices by using a critical perspective lens to eliminate systemic oppression in education (Giroux, 2004; Kincheloe, 2004; Leistyna, et al., 2004). However, it should be noted that society also plays a role in transforming the educational system,
for example, local communities (i.e. parents and community activist) can support the needs of students (Epstein, 2001; Sanders 2001).

A critical perspective lens can be used to examine the interrelationship between ideology, power and culture as means to implement critical pedagogical principles that challenge dominant educational practices (Kincheloe, 2008). In terms of the educator, pre-service teachers need to develop a critical consciousness or “clarity” about the social, political, cultural and economic realities in societal institutions as means to transform these spaces to meet student needs (Bartolomé, 2004). Moreover, using a critical perspective lens in pedagogical practices allows students to become critical thinkers and active participants in the construction of their learning.

The nature of the classroom is diverse, and therefore, any instructional and pedagogical practices should mirror that diversity. Educators should not have prescribed and fixed pedagogical practices. A democratic education can only be achieved when others’ voices are acknowledged in the social, cultural and political construction of the educational system. Leistyna, et al., (2004) contends that it is the ‘marketisation of education’ that creates barriers to minorities accessing a democratic/equitable education (p.4). Specifically, these scholars highlight that the standardization of educational process/practices (i.e., tests, curriculum) is problematic when educating students of cultural, linguistic and social differences. Specifically, they claim that teachers adopt pedagogical strategies that reflect the state’s objectives – a standard approach to schooling. As a result, other voices are silenced by dominant educational discourses, which create systematic barriers of oppression for minority students.

The aforementioned scholars propose that critical inquiry is important in teacher development in order to successfully prepare pre-service teachers to teach diverse students. Kincheloe (2004) discussed the complexity of teacher pedagogy and the importance of teacher
education: “critical complex teaching involves teachers as knowledge producers, knowledge workers who pursue their own intellectual development” (p.50). According to Kincheloe, using a critical complex empirical knowledge about education provides opportunities for the inclusion of alternative/other forms of educational knowledge rather than traditional positivist perspectives on education. In the context of science education, there are alternative models of science education, such as urban science education, that use a critical approach to scientific literacy. This approach is significant because it examines science as more than a body of knowledge. By adopting a critical approach to scientific literacy, science learning goes beyond definitions, theories, and laws to real world applications that can be used to change the world. The educator and students co-construct the learning environment/space by sharing the ‘power’ in the classroom. As already stated, to create an inclusive and equitable science space it requires science educators to critique, reflect and interrogate their current pedagogical practices to determine whether they are meeting the sociocultural needs of students. The social transformation of school science can only occur if educators understand how knowledge, power, and culture dynamics affect the access to scientific literacy development of students in these spaces.

Antiracism educational discourse focuses on the institutionalized racism inherent in educational processes, which creates a system of oppression and discrimination for minority students within schools (i.e., non-Whites) (DeCuir & Dixson, 2004; Dei 1996a, 1999, 2006, & 2010; May, 1994). Niemonen (2007) refers to “racism [as] an epistemology that privileges Eurocentric values, beliefs, and practices” (p.161). A major criticism of Western education is that it normalizes notions of Whiteness thereby creating social injustices and inequities for minority students. Whiteness is a social construct that symbolically privileges Whites in a position of power. As a paradigm, Whiteness becomes normalized within dominant/hegemonic
societal spaces/sites that systematically disadvantage others (i.e. racial/ethnic minorities) (Garner, 2007; Cooks & Simpson, 2007). Knight (2008) discusses the notion of the “invisibility of whiteness” (p.92) and how Whiteness benefits/privileges Whites and disadvantages others.

Further, critical educational scholars claim that Whiteness is the dominant cultural discourse in educational institutions. As a result, White teachers in particular must critically interrogate their racial identity in order to understand how White privilege reproduces oppressive/inequitable structures school practices/processes and implications for schooling (Knight, 2008; McIntyre, 1997; Sleeter, 2004). Scholars characterize antiracism as a ‘political pedagogy’ because it requires the educational system (i.e., teachers, students, community) to work collectively and collaboratively to eliminate systemic racism inherent in educational processes. Some scholars argue that antiracism education is a more effective pedagogy than multicultural education because the latter focuses primarily on cultural inclusion/awareness and does not address racism and/or social inequalities/discrimination in educational institutions (Carr & Klassen, 1996; Morelli & Spencer 2000; Niemonen, 2007).

Miner (2007) cites Enid Lee’s stages for implementing an antiracist education. First, the surface stage, in which others culture is included in the school. Second, the transitional stage, where educators create units of study on a group of people or an area. Third, is the structural stage, when the aforementioned units are integrated into mainstream curricula. Last, is the social change stage where students actively use the curriculum to transform the local community. Carr and Klassen (1996) contend that antiracist education allows teachers to become active participants in teaching diverse students how to be critical thinkers, and thereby bring about social change in education. They analyzed the perceptions of White and racial minority teachers concerning antiracist education in the Toronto Board of Education and found that White teachers
have different “views on antiracist education” than racial minority teachers. One of the findings showed that some White teachers feel that antiracist education is not important in certain disciplines, such as mathematics and science, for them only academic achievement mattered. This finding is significant because it suggests that some educators are *unconscious* of the sociocultural context and inherent biases/inequity in all school disciplines.

Mansfield & Kehoe (1994) contend that the failure of educators to adopt antiracist pedagogical practices is because most educators view curriculum as apolitical rather than political. The notion that Western school science is universalistic is controversial because all knowledge is subjective and constructed within a social, cultural and political framework. The failure of some educators to view school science as a ‘culture’ and ‘political’ demonstrates the challenges of changing the educational system. Moreover, despite the fact that school boards may have antiracist and equity policies, some educators have a limited understanding of how these policies can be implemented in school spaces. According to Gérin-Lajoie (2008), official documents, such as Ontario Ministry of Education guidelines, do not provide clear expectations on how to collectively implement equity and inclusive educational models/practices in mainstream classrooms (p.9). This suggests that there is a lack of socio-political ‘connection’ between the state, school and local communities, which has implications for the overall effectiveness and/implementation of school policies. Educational scholars argue that antiracism education is about identifying how educational systems reproduce oppressive and dominant societal orders and inequitable power relations between majority and minority students. However, in order to change dominant school discourse it requires a collective effort between all educational stakeholders (Gérin-Lajoie, 2008).
In my research study I used an antiracism and critical pedagogy theoretical approach as the conceptual framework. My research question centers around examining/analyzing elementary teachers’ perspectives on teaching science to socio-culturally (i.e. race, ethnic, social class, language, gender) diverse students. My objective was to examine the ways in which power structures and power relations of difference in school science spaces affect minority students’ scientific literacy development and achievement. Educational scholars claim that there exists a discrete “colourline” (Farley, 1997, p.459) between the educational experiences of racialized minority students and majority students in public school institutions (Dei, 1996a; 1996b; 1999). As a result, it is important to examine how the “colourline” is reproduced in science educational processes in order to effectively ‘socio-transform’ schools science spaces to meet the needs of minority/marginalized students. Moreover, I used the lens of critical pedagogy to deconstruct elementary educators understandings of student diversity issues in science education. My objective is to have educators critically reflect on how they develop minority/marginalized students’ success in science. Kincheloe (2008) states the following, “critical pedagogy works to provide such assistance to teachers who want to mitigate the effects of power on their students” (p.9). Also, “critical [pedagogy is] concerned with creating a social and educational vision to help teachers direct their own profession practice” (p.9). By using an antiracism pedagogical framework it allows for educators to become ‘critically conscious/aware’ of student diversity issues in science education. As a result, I hope my research study will highlight inequitable power dynamics/structures that exist in school science and possibly lead to discussions on how to positively /transform school scientific literacy practices and processes to equitably address the needs of minority/marginalized students.
Chapter Three: Research Methodology

The focus of the study was to investigate elementary educators perspectives on teaching science to socio-culturally diverse students. In addition, critically examine official discourses (i.e., Ontario Ministry of Education) on student diversity issues in the Ontario educational system.

In this chapter, I identify and describe the research methodology applied in my study. Specifically, I discuss the key features of qualitative research, semi-structured interviews and document analysis. In addition, I explain my rationale for using these techniques in my thesis. In the second section I discuss my empirical study.

3.1 Qualitative Research

Qualitative research is an approach that encompasses multiple theoretical paradigms, methods and approaches, such as case study, participatory inquiry, interviewing, participant observation, visual methods and interpretive analysis (Denzin & Lincoln, 2005). Merriam (2009) states, “qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences” (p.5). The qualitative researcher is an “interpreter” using a “naturalist approach” to construct meaning from individuals’ complex lived experiences/realities. The qualitative researcher is often referred to as a “bricoleur” (Denzin & Lincoln, 2005). Specifically, the bricoleur is described as a “handyman or handywoman who makes use of the tools available to complete a task” (Kincheloe & Berry, 2004). Arguably, the challenge for a qualitative researcher would be constructing the research study, in particular choosing the appropriate tools/methods. Moreover, the qualitative researcher must consider how individual/personal experiences and
sociocultural identity/reality affects the research – as qualitative research is an interactive process (Denzin & Lincoln, 2005). Overall, qualitative research allows the researcher to use multiple interpretive practices and theoretical paradigms for data collection and analysis. For my research study, I am using the theoretical paradigms of critical pedagogy and antiracism to make sense of science educators realities/perspectives developing minority students’ scientific literacy.

3.2 Semi-structured Interviews

Interviewing is commonly used as a form of data collection in qualitative research, specifically in the field of education. According to Warren, et.al, (2001) the “purpose of most qualitative interviewing is to derive interpretations, not facts or laws”, in order to derive meaning or understanding of individuals’ experiences (p.83). As such, the interviewer is able to choose from various types of interviews based on the amount of “structure”: highly structured, semi-structured, or unstructured. According to Merriam (2009) less structured interviews, such as a semi-structured interview is typically used in qualitative research studies. Semi-structured interviews are based on an open model framework where the researcher uses prompts/probes and proposes open-ended/flexible questions. Also, the respondents are given the opportunity to expand their ideas and discuss topics/themes/questions at length (p.90). My research study is based on teachers’ perspectives about minority student science learning. As a result, using a semi-structured interview approach allowed me to gather in-depth information on the topics of study.
3.3 Document Analysis

Document analysis is an analytical tool used in qualitative research. Bowen (2009) defines document analysis as “a systematic procedure for reviewing or evaluating documents—both printed and electronic (computer-based and Internet-transmitted) material” (p.27). Altheide (1996) states that “documents are studied to understand culture or the process and the array of objects, symbols, and meanings that make up social reality shared by members of society” (p.2). He identifies three types of documents, of which I will provide a brief summary: (1) primary documents are the objects of analysis/examination in the research, for example, newspapers, diaries, speeches, and magazines; (2) secondary documents are written records based on primary documents and other objects of research, such as field notes and published reports; (3) auxiliary documents are supplementary documents that may be relevant to the researchers study, but are not primary documents.

In the analytical process, data is extracted from documents (Corbin & Strauss, 2008; Rapley, 2007) that can be organized into themes/categories (Labuschagne, 2003) for interpretation. Document analysis is most commonly used in combination with other research tools. Bowen (2009) identifies five specific functions of documents, which is summarized as follows: (1) documents can provide data that can be used to contextualize research studies; (2) information contained in documents can suggest some questions that need to be asked and situations that need to be observed as part of the research; (3) documents provide supplementary research data; (4) documents provide a means of tracking change and development; (5) documents can be analyzed as a way to verify findings or corroborate evidence from other sources. Despite the various functions of documents, researchers must critically evaluate and examine documents to ensure the validity or authenticity of content (Bowen, 2009). In my
research study, document analysis is used to critically analyze documents in order to interpret themes/codes from the official literature on student diversity and science education.

### 3.4 Data Collection

Data collection consisted of semi-structured interviews and document analysis. In the following section I outline the processes I used to collect data for my research study.

The eight participants in the study are colleagues and friends of mine who have taught science in various middle schools in the Greater Toronto Area. As previously mentioned, elementary educators were selected as participants in the research study because research shows that elementary educators lack the expertise, or training to effectively teach science to students (Hoffman & Stage, 1993; Sagan, 1989). As a result, I chose to explore elementary educators’ perspectives on teaching elementary science to socio-culturally diverse students. Participants were selected based on the following criteria: (1) each participant had at least four years of teaching experience. Also, each participant had to be familiar with the Grades 1-8, Science and Technology curriculum document, in particular the program considerations. (2) Participants were chosen based on their diverse sociocultural identities/backgrounds (e.g., race, gender, ethnicity, age, sexual orientation) in order to obtain multiple perspectives on the topic of study. (3) Each participant had experience working in a GTA public school and community with a large population of socio-culturally diverse/minority students. By interviewing teachers that had experience working with diverse students it brought a sense of authenticity/reality to the research data. During the semi-structured interviews, I proposed sixteen open-ended questions covering three general categories: (1) professional background in science education; (2) scientific literacy development of minority students; and (3) official discourses on student diversity and science
education (Appendix 1). Each interview was approximately 1.5 hours in length. All of the interviews were digitally recorded and transcribed at a later date for analysis.

Second, document analysis was used to analyze the Ontario Ministry of Education documents on issues of student diversity and science education. In the context of education, public documents such as curriculum documents or ministry policy guidelines are important because it allows the qualitative researchers to follow a “paper trail” (Patton, 1980, p.152) about a topic, which may provide important information to help contextualize the researchers’ study process. In my research study the following Ontario Ministry of Education documents were critically analyzed:

- *Realizing the Promise of Diversity. Ontario’s Equity and Inclusive Education Strategy* (2009a)
- *Policy/Program Memorandum No.119: Developing and implementing equity and inclusive education policies in Ontario schools* (2009b)
- *Equity and Inclusive Education in Ontario Schools. Guidelines for Policy Development and Implementation* (2009c), and

### 3.5 Data Analysis

Coding is a means of organizing qualitative data by summarizing, reducing, or condensing it, in order to develop concepts, topic, ideas, categories, and themes (Coffey & Atkinson, 1996). Specifically, coding allows the researcher to identify meaningful data that can be used in the analytical process of inference and interpretation. Hahn (2008) cites three levels of
qualitative coding: (1) Initial coding or Open Coding where large quantities of research data are focused and labeled; (2) Focused Coding or Category Development where reexamination of level one codes and data is further focused; (3) Axial or Thematic Coding which results in the development of themes.

I began the process of data analysis by transcribing the digital recordings of the eight participants semi-structured interviews. First, I labeled the transcripts by highlighting words and or single phrases in the data and then through the analytical process of interpretation I assigned codes to the data. Second, I examined and compared the initial codes for patterns and organized similar codes into categories and subcategories in order to derive meaning from the data (Saldaña, 2009). Lastly, the categories and subcategories were reexamined for major themes present in the data. Saldaña (2009) states the following, “a theme is an outcome of coding, categorization, and analytic reflection, not some- thing that is, in itself, coded...(p.13)”.
Specifically, I reviewed the data and codes with my research study question in mind and identified two major emerging themes from my analysis.

The mixed model approach to coding was used to analyze the Ontario Ministry of Education documents. Prior to the initial coding of the Ministry documents, I created a list of predetermined codes that related to my research study, such as equity, diversity, inclusion. Afterwards, I used the same approach to coding as mentioned in the data analysis section of this section. Overall, my data analysis was based on my findings from the qualitative data (i.e. semi-structured interviews) in respect to the academic literature and the Ontario Ministry of Education policy documents.
3.6 Ethical Considerations

My position as a middle school elementary science educator might contribute to personal bias towards a specific scientific epistemological belief about science education and student diversity issues. Moreover, I have a personal relationship with these educators, where I might have had preconceived notions about the participants’ perspectives on the research study. Consequently, to avoid bias in my research I tried to ensure the validity of my data collection and analysis. First, I ensured that I chose participants of various sociocultural backgrounds in order to acquire multiple perspectives on the topic. Second, if participants expressed concerns about the privacy issues concerning the study I clearly stated that all digital audio recordings, written transcriptions, and notes would be erased upon completion of the study. Moreover pseudonyms were used in place of school and participant names to ensure that the identities of the elementary educators remain confidential.
Chapter Four: Document Analysis

In the past few years, the Ontario Ministry of Education has focused on eliminating systemic barriers and discriminatory biases in Ontario schools by adopting an equity-inclusive education policy. In 2009 the ministry proposed the Ontario Equity and Inclusive Education Strategy, a four year plan designed to increase equity and inclusive education in Ontario schools (Ontario Ministry of Education, 2009a, 2009b, 2009c). The Ontario Ministry of Education (2009b) defines the notion of equity as: “a condition or state of fair, inclusive, and respectful treatment of all people. Equity does not mean treating people the same without regard for individual differences” (p.90). Moreover, inclusive education is defined as “education that is based on the principles of acceptance and inclusion of all students. Students see themselves reflected in their curriculum, their physical surroundings, and the broader environment, in which diversity is honoured and all individuals are respected” (p. 90). The strategy is reinforced by a policy where school boards are mandated by the ministry to develop and implement an equity and inclusive education policy in their local schools. Overall, the ministry’s strategy calls for an epistemological shift in educational practices/processes, in Ontario, which affects the entire educational community and general understandings of student diversity.

My research study critically examines science educators’ perspectives on the sociocultural diversity of students and science education. Several official documents, in particular the Ontario Ministry of Education policies and curriculum documents, specifically address issues of equity, inclusion, and diversity in schools and science education. These official documents have direct implications for educators as the policies and curriculum may implicate on the pedagogical practices utilized by teachers in school science spaces. Critical analysis of these documents will allow me to gain critical understanding of some of the issues pertaining to
my research study. I examine the following documents: (1) *Realizing the Promise of Diversity: Ontario’s Equity and Inclusive Education Strategy*; (2) *Policy/Program Memorandum (PPM) No. 119, “Developing Equity and Inclusive Policies in Ontario schools”*; (3) *Equity and Inclusive Education in Ontario Schools: Guidelines for Policy Development and Implementation*; and (4) the “*Ontario Curriculum Grades 1-8, Science and Technology, Revised (2007)*”.

In the first section of my document analysis I discuss the contents of each of the aforementioned documents, where I highlight key ideas and themes presented in the official texts. The Ministry documents provide the educational community with a framework for addressing student diversity issues in Ontario schools. The Ministry accounts for the sociocultural diversity of students by outlining the educational practices/processes needed to ensure equitable and inclusive school spaces. In the second section of my document analysis, I critically analyze the stipulated role for educators in the documents, in particular, the role of science educators in the “*Ontario Curriculum Grades 1-8, Science and Technology, Revised (2007)*” document. Overall, the documents have implications for all educational stakeholders, specifically educators, who are primarily responsible for the academic success/achievement of all students. In the context of science education, critical analysis of the science curriculum document, in the context of equity, inclusion, and diversity is necessary in order to understand how, and why these revisions affect the scientific pedagogical practices of educators’ and the science-learning experiences of socio-culturally diverse students.

### 4.1 Section 1: Equity and Inclusive Education Policies in Ontario

In 2009 the Ontario Ministry of Education devised the strategy document, “*Realizing the
Promise of Diversity: Ontario’s Equity and Inclusive Education Strategy”, which outlines how key educational stakeholders, such as the Ministry, school boards, and schools can support equity and inclusive education models in Ontario publicly funded schools. The Ontario Minister of Education at the time Kathleen Wynne, stated that in this document that student achievement/success is achievable if school spaces are equitable and inclusive. In addition, an inclusive and equitable school system is fundamental to ensuring that students become active, highly productive, and responsible citizens in society. The document is divided into several categories, which outlines the Ministry’s policy and expectations for implementing an equity and inclusive education strategy in Ontario schools. In the following paragraphs, I discuss the major ideas/themes present in the policy document.

Ontario’s Equity and Inclusive Education Strategy

First, equity and inclusive educational models will allow students to experience success or higher academic achievement. According to the Ministry of Education an equitable and inclusive education system is necessary in order to achieve the following three core priorities: (1) high levels of student achievement; (2) reduced gaps in student achievement; (3) increased public confidence in publicly funded education. Ontario schools are becoming increasingly complex due to the highly diverse and multicultural nature of schools. As a result, the Ministry (2009a) proposes a need for action in the form of an equity and inclusive education strategy. The strategy is designed to identify systemic barriers, power dynamics and discrimination (e.g., racism, homophobia, sexism, etc.) that may be embedded in schools space. The three major goals of the equity and inclusive education strategy are as follows: (1) shared and committed leadership by the entire educational system (i.e., Ministry, boards, and schools) to eradicate
discrimination by identifying systemic biases, barriers and discrimination; (2) \textit{equity and inclusive education policies and practices} must support positive learning and welcoming environments where students, staff, and teachers are respected; and (3) \textit{accountability and transparency} will be demonstrated using clear measure or established indicators of success that is to be communicated to the public on an ongoing basis.

Second, the Ministry’s vision for an inclusive educational system is a collective group effort. However, it is the school boards and local schools that are responsible for implementing and assessing the policy. The Ministry states the following: “to achieve an equitable and inclusive school climate, school boards and schools will strive to ensure that all members of the school community feel safe, comfortable, and accepted.” (p.10). The Ministry’s objective is to create a four year (2008-2012) strategy plan, where within that time the school boards implement their own equity and inclusion policy based on Ministry guidelines. In addition, schools are required to create their own equity policies and practices based on the directives of local school board. The Ministry provides a detail list of suggested “action items” (p.18) that both the ministry and school board should achieve during the four year time period. Even though the Ministry states that in the first two years they will provide financial and logistical support (e.g., funding, training, professional development, curriculum revision) it is the school boards and schools that assume the majority of the responsibility. Ultimately, the school boards that assume the primary role of devising and constructing the equity and inclusion based practices/processes that are to be implemented in schools.

Last, the overall effectiveness of the equity and inclusion education policy will be based on the evaluation/assessment measures utilized by school boards. The Ministry states they will monitor the implementation of equity and inclusive education policies in school boards.
However, the evaluation of the policies is the responsibility of the school boards, and therefore subjective. In the document, the Ministry does not provide school boards with any standard guidelines on how to evaluate their policies. As a result, each school board will have measures of assessing/evaluating the success of their equity and inclusion educational policies.

**Policy/Program Memorandum (PPM) No. 119**

In 1993, the Ontario Ministry of Education issued the policy directive, Policy/Program Memorandum No. 119, “Development and Implementation of School Board Policies on Anti-Racism and Ethnocultural Equity” where school boards had to adopt antiracism and ethnocultural policies that focused specifically on race relations issues in educational institutions. However, in 1995, when the Progressive Conservative government came into power, the equity policy guidelines where no longer enforced (i.e. implemented or monitored) in school boards, which halted any type of anti-racist initiatives and reforms in the Education Ministry (Corson & Shaker, 2001).

Dei (2003) argues, even though the policy had minimal success at the school board level, the policy addressed various equity issues (e.g., anti-homophobia, socioeconomic differences, gender, and disability) and was used as a framework for equity policies in school boards, such as the Toronto District School Board. However, in 2009 under the Liberal government, the Ontario Ministry of Education issued “Policy/Program Memorandum (PPM) No. 119, Developing and implementing equity and inclusive education policies in Ontario schools” (2009c), which replaced the 1993 policy/memorandum and focused specifically on the notions of an equity and inclusion model. Specifically, No. 119 (2009c) provides direction to school boards on the review, development, implementation and monitoring of equity and inclusive education policies
to support student achievement. The policy is significant in that school boards are mandated to promote fundamental human rights as described in the Ontario Human Rights Code, Canadian Charter of Rights and Freedom, and the provincial Code of Conduct. The policy is divided into four main categories: (1) *Background*, which discusses the progression of policies on equity and inclusion issues in Ontario. The major difference between the 1993 and the 2009 policy guidelines is that the former focuses on racism where the latter examines the intersectionality of oppressions (i.e., race, sexual orientation, physical or mental disability, gender, and class); (2) *Requirements for Boards*, the ministry states that beginning in September 2010, the boards will have the following things in place: equity and inclusive education policy, a guideline on religious accommodation, and an implementation plan. In addition, the boards must ensure that all board policies and procedures reflect the equity and inclusive education policy. The school board’s equity and inclusion policy should be grounded in the fundamental principles of the Ontario Human Rights Code and Canadian Charter of Rights and Freedom. (3) *Policy Development*, the Ministry states that school boards should focus on the following eight areas for development and implementation: (a) Board policies, programs, guidelines, and practices; (b) Shared and committed leadership; (c) School–community relationships; (d) Inclusive curriculum and assessment practices; (e) Religious accommodation; (f) School climate and the prevention of discrimination and harassment; (g) Professional learning; and (h) Accountability and transparency. (4) *Implementation* of the strategy is a three-year plan that will be monitored annually by the Board, where both the school boards and schools should establish annual objectives, measurable outcomes, partnerships (i.e., parents, communities), and evaluation indicators/measures.
Guidelines for Policy Development and Implementation

The Ministry’s “Equity and Inclusive Education in Ontario Schools: Guidelines for Policy Development and Implementation” (2009c) is a guideline document that is based on the principles and commitments of the Ministry’s, Realizing the Promise of Diversity: Ontario’s Equity and Inclusive Education Strategy and Policy/Program Memorandum (PPM) No. 119 (2009) documents. The guidelines describe in detail several strategies, examples and templates for developing, implementing, and monitoring an equity and inclusion education policy. The document is divided into five sections, which are discussed briefly below.

First, the introduction of the document reviews the legislative and policy context and historical context of the guidelines. Specifically, the Ministry expects school boards to create an equity and inclusion policy that reflects the Ontario Human Rights Code and review an existing or develop a new religious accommodation that is to be communicated to the school community. Historically, the Ministry has been committed to establishing polices in Ontario that support equity, human rights, and social justice issues in education. Most notable is the former PPM, No.119, “Development and Implementation of School Board Policies on Antiracism and Ethnocultural Equity” (1993), which directed school boards to develop a policy on antiracism and ethnocultural equity. As already discussed, this policy was considered to be important because it addressed the Eurocentric nature of education and issues of systemic racism and discrimination against minority groups in school institutions.

Second, policy development is the Ministry’s expectation that school boards construct equity and inclusion education policies grounded in the Ontario Rights Human Code and the eight areas of focus as outlined in the Policy/Program memorandum No.119. The Ministry provides detailed action items by areas of focus, which specifically address things that boards
and schools can do in support of the policy. The Ministry expects that each board will have a different equity and inclusion policy because the policy should reflect the needs of the local community (e.g., geographical considerations, demographics, cultural needs, and the availability of board and community support and resources).

Third, *implementation* is the collective effort that involves all education and community stakeholders, including parents, staff, and students. According to the Ministry the development and implementation of an equity and inclusive educational policy is a three-year process that should include the following: (1) the board’s vision and mission statements; clearly stated annual objectives and measurable outcomes at both the system and the school levels; (2) procedures and indicators for annually measuring and evaluating progress; and (3) a description of active and ongoing partnerships. In addition, the school board’s implementation plan should clearly address all eight areas of focus in PPM No. 119.

Fourth, *monitoring and reporting* is to ensure that school boards are meeting the expectations and/or goals of the Ministry’s equity and inclusion education strategy and PPM No. 119. It is also to show stakeholders (i.e. parents, staff, community members, public) the progress of the policy in terms of reducing student academic achievement gaps. Specifically, the board is to report progress in the Director of Education’s annual report, which includes the revised or new equity and inclusive education policy, the religious accommodation guideline, progress on achieving the equity goals in the board’s improvement plan, and, flowing from the board’s cyclical review of other policies, details of progress in embedding the principles of equity and inclusive education into all aspects of the learning and working environment. Data is collected through words, numbers, or observations and used as evidence to inform decision making, and/or, used to develop effective practices, in regards to increasing student achievement and
reducing the student achievement gap. In the document the ministry provides guidelines on how data is to be collected and the reporting progress.

Last, tool and resources are located at the end of the document, which includes a “Sample Policy for Public District School Boards” and an “Alternative Policy Statement for Catholic District School Board”. The sample policy document is comprised of a policy statement and the areas of focus, which discusses the board’s commitment to the principles found in the Ministry’s Ontario’s equity and inclusive education strategy, PPM No. 119, Canadian Charter of Rights and Freedoms, the Constitution Act, 1982, and the Ontario Human Rights Code.

**Ontario Curriculum Grades 1-8, Science and Technology, 2007 (Revised)**

Over the past few years the Ministry has implemented programs and initiatives that are directly related to the equity and inclusive education strategy, such as curriculum revisions. Beginning in September 2008, all science and technology programs had to be based on the expectations found in the revised version of The *Ontario Curriculum, Grades 1-8: Science and Technology*, 2007. The document is organized in five sections: (1) an introduction, which discusses the goals, nature, and roles and responsibilities in the science and technology program; (2) science and technology programming, which refers to the curriculum expectations, strands, skills continua, and various topics in the science and technology curriculum; (3) assessment and evaluation of student achievement, which includes basic considerations and an achievement chart; (4) some considerations for program planning in science and technology (5) curriculum expectations for Grades 1-8.

The *Ontario Curriculum, Grades 1-8: Science and Technology, Revised (2007)* document is significantly different from the 1998 version, in that the principles of equity,
inclusion and diversity are evident within the contents of the document. First, in the introduction the Ministry clearly states that the achievement of both excellence and equity underlies the three major goals of the science and technology program at the elementary level. Second, the programming in science and technology should be inclusive and reflect the diversity of the student population and the population of the province. Third, teachers should adopt varied assessment and evaluation strategies, in order to eliminate any discriminatory biases and improve student learning. Fourth, the Ministry discusses in detail some considerations for program planning in science and technology, which clearly acknowledge the relationship between students’ diversity and science learning. For example, the Ministry includes the following considerations: instructional approaches, special education, English language learners, antidiscrimination, and critical thinking and critical literacy. Last, the Ministry provides suggestions on how the curriculum expectations can be implemented by using sample-guiding questions, sample issues, or sample prompts. Some of these samples are more current and relevant and include cultural references, for instance Aboriginal perspectives.

4.2 Section Two: The Role of the Educator in Addressing Student Diversity Issues

In this section, I analyze the role of the educator in the aforementioned documents, in order to understand how these ‘official documents’ affect educators’ pedagogical practices. I critically examine how the revisions to the elementary Ontario science and technology curriculum address issues of equity, inclusion, and diversity in school science spaces.

As already mentioned, there are three key stakeholders in the implementation of Ontario’s Equity and Inclusive Education Strategy (2009a): the Ministry, school boards, and schools. The role of the Ministry is to provide school boards with policy guidelines, support (i.e.
logistical and financial), and monitor the implementation of board level equity policies. School boards assume the majority of the responsibility, where boards must oversee the development, implementation, evaluation, and revision of policies. Schools must adhere to board directives on policies and implement them in the schooling processes. To address achievement gaps amongst students in Ontario, the Ministry of Education proposes equity and inclusive educational models in local schools. The Ontario Equity and Inclusive Education Strategy is to be implemented over a four-year period, which was to be completed by the end of the 2012 academic school calendar.

The transformation of Ontario schools, in the context of equity and inclusion has significant implications for the pedagogical practices/processes of educators within school spaces. In the following paragraphs I critically analyze how the aforementioned ministry documents (2009a, 2009b, 2009c, & 2007) address the role of educators in the equity and inclusion policy strategy and implications for educators teaching diverse students.

The “Realizing the Promise of Diversity: Ontario’s Equity and Inclusive Education Strategy” (2009a) document acknowledges that the construction of an inclusive educational system in Ontario requires the efforts of the entire educational community. Educators play a pivotal role in the Ministry’s strategy, in particular educators share in the commitment and leadership of incorporating equity and inclusive principles in the classroom and school environment. According to the Ministry,

[Ontario] schools should be places where students not only learn about diversity but experience it. We know that, when students see themselves reflected in their studies, they are more likely to stay engaged and find school relevant. Revised curriculum documents now contain a section on antidiscrimination education and examples that help teachers better connect with the reality of students’ lives. (p.15)

Consequently, educators need to be conscious of student differences in their classroom and actively implement pedagogical practices that reflect all students’ diverse backgrounds.
Specifically, the Ministry proposes the use of differentiated instruction to meet individual student learning needs. Educators will be provided with training and resources on differentiated instruction, in order to address students’ different learning styles.

Differentiated instruction is considered to be an effective approach to teaching and learning because it takes into account the students’ individual needs, which is supposed to increase the chances for student success/improvement. The Ministry (2010) defines differentiated instruction as:

An approach to instruction designed to maximize growth by considering the needs of each student at his or her current stage of development and offering that student a learning experience that responds to his or her individual needs. Differentiated instruction recognizes that equity of opportunity is not achieved through equal treatment and takes into account factors such as the student’s readiness, interest, and learning preferences. (p.146)

However, it should be noted that not all school communities are the same. As a result, using a differentiated instructional approach may prove to be challenging for some educators due to the nature of their classroom environment. In addition, some may argue that using a differentiated approach is difficult when educators may have to deal with other issues such as time and planning constraints, lack of resources, administration, and parental or community support, and teacher-student relationships. Overall, as a pedagogical approach, educators would need to acquire the skills to effectively use differentiated instruction in classroom practices.

The Ministry acknowledges the importance of providing educators with professional learning in the areas of equity and inclusion as means to reduce gaps in student achievement. There are several initiatives that focus on the interrelationship between student learning and teacher professional development. The initiatives are listed in the appendix of the document and include policies, strategies, and programs. Most notable is the revised curriculum documents which contain a section on antidiscrimination education and provides teachers with concrete
examples on how to make school curricula meaningful to students’ and their lived experiences. The changes to the curriculum have significant implications for educators because they are expected to incorporate equity and inclusive based principles/practices into instructional approaches, learning resources, and assessment and evaluation practices. Professional learning is critical because it allows educators to improve and transform their pedagogical practices based on the needs of students. However, it is at the boards’, and therefore the schools’ mandate to provide educators with training in the area of equity and inclusion.

Similarly, the “Policy/Program Memorandum (PPM), No. 119” is a document outlining for school boards (i.e., of education, superintendents, and principals) the Ministry of Education’s expectations regarding the development and implementation of the equity and inclusive education policy strategy. One of the major themes evident in the document is the need for boards to collaborate with the educational community in order to successfully develop and implement the policy. In the memorandum, the Ministry briefly describes the eight areas of focus that need to be covered in a board’s equity and inclusion policy. Undoubtedly, all of the eight areas require the support of educators.

However, it is the following two areas, inclusive curriculum and assessment practices and professional learning, that highlight the importance of educators in the policy. First, inclusive curriculum and assessment practices utilized by teachers should reflect students’ sociocultural diversity (i.e., culture, ethnicity, language, and class). Also, educators should use teaching and learning and assessment/evaluation strategies outlined in curriculum policy documents as means to improve student learning and eliminate any systemic barriers. Second, the board should provide educators with professional learning opportunities in several equity and inclusion related topics, such as antiracism and antidiscrimination. It cannot be assumed that educators are
conscious or unconscious of the systemic barriers that exist in education. However, there is a need for educators to become actively critical and reflective in their teaching practices as means to develop concrete understandings of student diversity issues. Educators are responsible for constructing inclusive classrooms in accordance with the board’s policy on equity and inclusion. Overall, policy guidelines highlight the need for school boards and schools to be held accountable for implementing educational practices/processes that are equitable and inclusive. As a result, educators need to be well equipped in order to bring about the socio-transformation of the classroom environment, which requires the support of boards and the Ministry.

Comparatively, the “Equity and Inclusive Education in Ontario Schools: Guidelines for Policy development and Implementation” document provides school boards with detailed guidelines on how to implement an equity and inclusive education policy in schools. However, in the document, the Ministry highlights some key themes and ideas that may have implications for educators. First, the Ministry places a strong emphasis on parental or guardian involvement and engagement in schools. Specifically, one of the action items, school-community relationships, discusses in detail the importance of school boards and schools establishing close relationships and partnerships with parents. In the Ministry’s strategy, school boards are strongly encouraged to provide parents with opportunities to build collaborative-based relationships with the school system. This can be achieved by ensuring that parents of diverse sociocultural backgrounds contribute to the development, implementation, monitoring, and assessment and evaluation of school board policies and programs. Overall, the policy will provide parents with a voice in the school, as it is the Ministry’s expectations that boards create welcoming and respectful school environments (e.g., support and resources) where parents can become collaborative partners. However, in the document the Ministry does not discuss the differences between majority and
minority parents’ access and involvement in school system. Boards have to develop a policy to address discriminatory biases and systemic barriers in schools that affect minority parents’ participation in school processes/practices. Ultimately, if parents are actively involved in their child’s learning at school and home it will undoubtedly have a positive and significant impact on the child’s academic success. The overall success and legitimacy of a board’s equity and inclusion policy is contingent on parental support or engagement. Boards are held accountable by parents for providing safe, equitable, and inclusive school environments for their children. Hence the primary role of the educators is to build strong parent-teacher relationships by working with parents to remove systemic barriers in the classroom.

Second, developing strong school-community relations with various groups, such as universities and faculties of education, teachers’ federations and associations, unions, service organization, etc., is an important theme in the Ministry’s equity and inclusion strategy policy. The broader community can provide boards and schools with support, resources (i.e., financial and personnel), and information and knowledge about the sociocultural (i.e., linguistic, cultural, religious, economic) needs of the surrounding school communities. Moreover, the involvement of the community is necessary to ensure that board policies reflect the diverse nature of the local community. Community access to classroom via workshops, such as lectures, program, resources, and field trips can result in positive educational outcomes (i.e., reduced achievement gap and overall student improvement). As a result, in the classroom educators may use the community as an educational resource to enhance pedagogical practices and to make learning experiences more meaningful for diverse students. It is made clear by the ministry that the community shares in the responsibility in the educational systems. It is the expectations that school boards involve the community in the development and implementation of the equity and
inclusion policy. The involvement of community partners is significant because it highlights the need for all educational stakeholders to be actively committed to an equity and inclusive educational model.

One of the major items that the Ministry proposed from the strategy was to incorporate equity and inclusive education principles in all curriculum and assessment policy learning resource documents. Subsequently, in 2007, the *Ontario Curriculum Grades 1-8, Science and Technology* document was revised to include equity and inclusion based principles.

In general, curriculum documents contain the Ministry’s ideas, objectives, goals, philosophy, learning expectations, instructional resources, and assessment and evaluation practices for science education in Ontario. Moreover, the curriculum provides educators with the Ministry’s ideologies about school science, which is to be reflected in the scientific pedagogical practices and processes utilized by educators in the class. In this regard, the 2007 document states the following about the goals of the science and technology program:

> Achievement of both excellence and equity underlies the three major goals of the science and technology program at the elementary level. Accordingly, The Ontario Curriculum, Grades 1–8: Science and Technology, 2007 outlines the skills and knowledge that students will develop, as well as the attitudes that they need to develop in order to use their knowledge and skills responsibly. The three goals are the following:

1. to relate science and technology to society and the environment
2. to develop the skills, strategies, and habits of mind required for scientific inquiry and technological problem solving
3. to understand the basic concepts of science and technology. (p.3)

Prior to the 2007 document the 1998, “*Ontario Curriculum, Grades 1-8: Science and Technology*” curriculum stated:

> The goals of science and technology education in Grades 1 to 8 follow from the nature of science and technology and from the needs of Ontario’s students discussed above. The goals are intended to ensure that all students acquire a basic scientific literacy and technological capability before entering secondary school.
The goals of student are:
- to understand the basic concepts of science and technology;
- to develop the skills strategies and habits of mind required for scientific inquiry and technological design; and
- to relate scientific and technological knowledge to each other and to the world outside of school. (p.3)

The three primary goals of the science and technology curriculum have not changed since the 1998 science and technology curriculum. However, seemingly the Ministry’s philosophy regarding science and technology education has changed. In the (2007) document there is emphasis placed on acknowledging the importance of scientific and technological literacy in all individuals’ lives, whereas the 1998 document highlights the goals as being important only for students acquiring basic scientific and technological literacy before entering high school. According to the Ministry, science and technology plays an integral role in students’ lives, as such, understanding life phenomena or experiences within a scientific and technological context is necessary. Despite variations in the Ministry’s objectives regarding scientific and technological education, the primary goals of the program remain the same. Even though the Ministry identifies the principles of excellence and equity as underlying the three goals of the science and technology program there is no explanation provided as to why or how these principles are reflected in the goals.

Moreover, the goals of the science and technology program do not reflect any of the principles of equity, inclusion, and diversity as discussed in the Ontario Ministry Education Strategy (2009a). For example, the Ontario Ministry of Education (2009a) describes inclusive education as an, “[e]ducation that is based on the principles of acceptance and inclusion of all students. Students see themselves reflected in their curriculum, their physical surroundings, and the broader environment, in which diversity is honoured and all individuals are respected” (p.4). Based on the Ministry’s definition of an inclusive education students’ diversity should be
reflected in the curriculum. However, the goals of the 2007 science and technology program do not explicitly address or acknowledge student diversity, which is not necessarily reflective of the principles of an inclusive educational model. Consequently, if the goals of the science and technology program do not incorporate principles of equity, inclusion, and diversity it does not suggest a systematic transformation in science and technology education, in the context of student diversity issues in science education.

Nonetheless, in the 2007 science and technology curriculum document, the Ministry does include a comprehensive section on science program planning considerations, which highlights the need for science educators’ to be critically aware of the science pedagogical practices used in the classroom to develop the scientific literacy of sociocultural diverse students. These revisions are significant because the “Ontario Curriculum, Grades 1-8: Science and Technology” (1998) document did not contain a section on program planning considerations. Instead the document contains a section titled “planning student programs” (p.10) which did not address students’ sociocultural background (e.g., race, culture, language) but made reference to addressing the needs of exceptional (i.e., Individualized Education Plan) students in science programming. In comparison, in the 2007 document, the Ministry attempts to address the interrelationship between students’ sociocultural background and science literacy development.

First, it is expected that educators diversify their science instructional practices to account for students’ individual learning interests, abilities (e.g., special education students), prior knowledge, and diverse personal and cultural experiences (e.g., race, class, gender, language). Furthermore, students should engage in scientific and technological processes that have real world applications and science learning should be primarily based on an inquiry-based, and or, hands on (i.e., concrete) approach. It is the Ministry’s understanding that science educators need
to be aware of students’ diversity as means to effectively use instructional practices that engage students in science learning. As a result, science learning can become an individualized learning experience for students, where the educator is using practices and processes that address the students’ individual needs. This is significant because it challenges traditional notions that science learning is an objective or universal process. Consequently, educators must acknowledge the sociocultural perspective of science and construct different ways of science learning that reflects the students in the class.

To that end, the Ministry advocates the use of inquiry-based instruction and hands-on or discovery experiments as means to actively engage students in understanding scientific knowledge and concepts. In addition, the Ministry does not account for differences between school boards, and or school communities, in terms of funding and resources for providing opportunities for hands on science programs. Ultimately, educators should not necessarily adopt prescribed pedagogical practices but critically examine the classroom space and identify instructional practices/strategies that meet the needs of students in the space. Nonetheless, science educators should actively use a variety of instructional approaches to teaching science that ensure that students of varying sociocultural backgrounds can access and make meaningful connections to school scientific knowledge (e.g., concepts and skills).

Second, the Ministry specifically highlights in the program planning considerations two ‘types’ of students: special education learners and English language learners. In terms of special education learners, educators must account for the accommodations and modifications that these students may need and use the appropriate science instructional and assessment practices. Similarly, educators have to use science pedagogical practices that support English language learners’ literacy development and include their cultural and linguistic experiences into the
science classroom space. However, if science educators are going to be able to create a supportive learning environment for these types of student then other support staff are needed, such as, special education teachers, ESL/ELD teaches and volunteers. Moreover, science educators have to work collaboratively with the ‘specialized teachers’ to ensure that the learning needs of these types of students are being met. Science educators should not be expected to be experts on understanding student diversity issues, but instead given opportunities to work closely with teachers who have training in these ‘specialized areas’. However, opportunities for ‘collaborative teaching’ will be challenged if the board is unable to provide the support and resources to assist science educators in diverse classrooms. Nonetheless, special education and ESL students are considered to be a high priority in the science classroom, and therefore, educators must program accordingly to meet the needs of all students.

Third, antidiscrimination education as a science and technology program consideration is based on the principle that students’ socio-culturally (i.e. gender, race, culture, and ability) should be reflected in science learning processes and practices. Science educators should create science classroom spaces that identify biases and any forms of discrimination that may affect diverse students’ scientific literacy development. For example, this can be achieved by educators becoming socio-culturally responsive in their pedagogical practices, such as using culturally sensitive learning materials, ensuring students have access to scientific tools and technology and making religious accommodations. An antidiscrimination approach to science education in schools is important to the Ministry’s equity and inclusive strategy, as it ensures that school science practices reflect the students’ within the local community. The objective is to ensure that students can make meaningful connections to science learning. Planning for the greater diversity in classrooms would mean that educators have to critically examine and reflect on their own
personal epistemologies and beliefs about Western science education practices and processes. However, as stated earlier it cannot be assumed that all educators understand what antidiscrimination is, and therefore, are capable of developing and implementing an antidiscrimination science education program. The Ministry only briefly outlines the various sociocultural issues in science education and cites simple examples of how educators can address these issues in science education. For example the Ontario Ministry of Education (2007) states the following:

[i]t is important that learning activities include opportunities for students to describe, study, or research how women and men from a variety of backgrounds, including Aboriginal peoples, have contributed to science and technology or used science and technology to solve problems in their daily life and work…There are also expectations in the curriculum that require students to look at the perspectives or world views of Aboriginal cultures as they relate to science and technology. (p.37)

In the Ministry’s statement there is this underlying assumption that educators are already ‘experts’ in implementing activities that address cultural diversity in science educational processes and practices. The Ministry’s acknowledges that there exist other forms of cultural scientific perspectives in science learning, which require student awareness. However, the Ministry only identifies Aboriginal culture, where the science curriculum expectations include specifically Aboriginal perspectives or worldviews as they relate to science and technology. Arguably, there are other groups that have made significant contributions to science, which are not explicitly identified in the document. As a result, it becomes the educators’ individual choice to acquire knowledge or understanding of other cultural forms of science and include these perspectives into their programming. Moreover, it should be noted that even though the Ministry has included Aboriginal perspectives on scientific phenomena in the curriculum it does not necessarily give an authentic ‘voice’ to the community. Hence the need for educators to avoid
essentializing or tokenizing cultures in their scientific pedagogical practices by possibly developing school-community partnerships with various cultural groups, as means to provide authentic science learning experiences.

Overall, the considerations highlight student diversity issues in the science classroom and the sociocultural nature of science education. However, there is a need for science educators to understand the complexity of addressing student’s backgrounds, experiences, and identities in scientific literacy development. Furthermore, educators need to be able to understand the power imbalances and social inequalities that exist within the science classroom, which create the need for an antidiscrimination science and technology program. The science program planning considerations are only ‘considerations’. Consequently, it would seem that it is only the primary responsibility of the educator to ensure that the science classroom is inclusive and equitable for students. However, it cannot be the sole responsibility of science educators to create inclusive science educational programs, as educators will require the resources and support of the whole system to transform the nature of the science classroom. Moreover, the Ontario Science and Technology curriculum (2007) is only a document. Arguably, it is the individualized nature of the science educator’s classroom and its learners that should determine the types of pedagogical practices and science programming that will be used to develop students’ scientific literacy. Nonetheless, the diverse student populations in Ontario schools would suggest that educators must construct classroom spaces that reflect student diversity and the principles of equity and inclusion, as proposed by the Ontario Ministry of Education.
Chapter Five: Elementary Educators Knowledge of Student Diversity Issues in Science Education

In section one of chapter five, I present the participants’ profiles\(^1\) and provide a brief description of the cultural identity of the participants and highlight their personal and professional background. In addition, I describe their current teaching position and identify the types of diverse learners in their classrooms. Each of the eight participants have at least five years of teaching experience in middle schools throughout the Greater Toronto Area (GTA). Moreover, the participants have experience teaching and developing an elementary science education program for socio-culturally diverse students.

In section two I will discuss elementary educators’ knowledge and or understanding of student diversity issues and science education. Specifically, I discuss the elementary educators perspectives on addressing students’ sociocultural backgrounds in science educational processes (i.e., teaching and learning), in relation to the Ministry’s policies on equity and inclusive education and literature review findings. That is, I examine elementary educators understandings of student diversity and the interrelationship between students’ sociocultural background and science education.

5.1 Section 1: Study Participants’ Background Information

**Ben**

Ben is a West Indian male of African descent. He has approximately 19 years of teaching experience. His teaching career started in the West Indies where he attended teachers college and taught elementary for seven years before coming to Canada to teach in various middle schools in

\(^1\) The names of the study participants used in the profiles are pseudonyms, in order to protect the participants’ privacy.
the Greater Toronto Area (GTA). He has basic qualifications in primary and junior divisions, senior division, Individual and Society, and intermediate division and Mathematics. Also, Ben has additional qualification in Computer and Special education (Specialist) and Principals Qualification (Part 1). He has spent the last four years as a Grade 6 Core (i.e., Language, Math, Science, Social Studies, and Drama/Dance) and In-School Support Program (ISSP) teacher at a middle school (Grade 6-8) located in a downtown suburb, in Southern Ontario, Canada. His current teaching position is comprised of two roles: (1) Grade 6 ISSP (In-School Support Program) teacher and (2) Grade 6 Contact teacher. Specifically, he works with students that require academic and social support; in particular these students receive program modifications, and/or accommodations in the classroom. He identifies the learners in his classroom as being sociocultural diverse and having learning and behavioral exceptionalities.

**Steve**

Steve is a White male of European descent. He has 11 years of teaching experience. He attended teacher’s college in Australia and afterwards spent one year in Japan teaching English as a Second Language (ESL) before returning to Canada to teach a Grade 5/6 class for two years in Brochet, Manitoba on a Cree reserve. Afterwards, he returned to Ontario to teach in several middle schools (Grade 6-8) throughout the GTA. He has basic qualifications in primary and junior divisions and intermediate division, geography. Steve has several additional qualifications, Special Education (Part 1), English as a Second Language (Specialist), Reading (Part 1 and 2), Mathematics, Primary and Junior (Part 1). For the past six years, Steve has taught Grade 6 Core (i.e., Language, Math, Social Studies, Science and Physical Education) in a middle school in a suburban area in the west end of Toronto. Currently he is teaching Grade 8 Language, Social
Studies, and Technology. He has a specialist in ESL where he works specifically with ESL and English Language Learners (ELL). In addition, he identifies the types of his learners as gifted, learning exceptional, and behavioural students.

**William**

William is West Indian male of African and East Asian descent and has six years of teaching experience in Ontario. His teaching career began during teacher’s college when he would occasionally volunteer as a supply teacher at his former high school in the northwest end of the GTA. He credits his volunteer experience as having a strong impact on his decision to pursue a career in elementary education. For the past six years he has worked in a highly socio-culturally diverse middle school located in a downtown suburb in Southern Ontario. His school has a large population of culturally diverse students, in particular students of East Asian and West Indian descent. William has basic qualifications in junior and intermediate divisions, Physical and Health Education. He also has additional qualifications in Health and Physical Education, Intermediate and Senior (Part 1). Currently, he is a Grade 6 Core (i.e., Language, Math, Social Studies, Science, Drama, and Physical Education) teacher and identifies the learners in his class as having different abilities, cultural backgrounds, behavioural issues, and ESL learners.

**Annie**

Annie is a Chinese-Canadian female. She has nine years of teaching experience in Ontario. Initially she had attended university to become a graphic designer, however, she dropped out of her program after one year of study. It was only when she student-volunteered at
her former elementary school located in the GTA that she realized her passion for working with children. Annie has basic qualifications in the primary and junior division and several additional qualifications: Reading (Specialist), Mathematics, Primary and Junior (Specialist) and Special Education (Part 1). She has been an elementary teacher for nine years working in primary/junior schools (K-5) in Southern Ontario. Her teaching career began working in an inner-city school in Southern Ontario, which she identifies as having highly diverse student populations. Annie has taught Grade 1 and 2, however, prefers teaching Grade 6. Over the past few years, in her Grade 6 classes she has worked specifically with ESL and ELL learners and special needs students who have both academic and social needs.

**Helen**

Helen is a White female of European-Canadian descent, who has 11 years of teaching experience in Ontario. She credits her own elementary school and volunteer experiences as having a strong impact on her decision to become a teacher. She grew up in Southwestern Ontario in a small rural area where she attended a K-8 school with a student population of approximately one hundred students. In high school, she spent her summer vacations volunteering at local camps teaching children about horsemanship and horseback riding. Initially Helen attended university to become a veterinarian, however, after two years of working on a dairy farm she decided to attend teachers college. She has basic qualifications in junior and intermediate divisions, Science-General, primary division, and senior division, Science-General. Also, additional qualifications in Special Education (Part 1), Learning Disabilities (Part 1), and English as a Second Language (Part 1). She has experience teaching both Grade 6 Core and rotary Science. Currently she is teaching Grade 6 Core (i.e., Language, Math, Science, Social
Studies, Drama, and Art) at a middle school located in a downtown suburb in Southern Ontario. She identifies a variety of learners in her classes, which range from gifted, ESL, ADHD, and Autistic learners.

**John**

John is a white male of European descent, who has five years of teaching experience in Ontario. He started his teaching career working as a supply teacher in various schools in the west end of the GTA. After one year of supply teaching he was offered a full time contract position as a Grade 6 In School Support Program (ISSP) teacher at a middle school in Southern Ontario. For the past four years John has worked with Grade 6 special education students (e.g., learning exceptionalities, ESL, behavioral) providing these students with academic support in all Core subjects, such as Math, Language, and Science. He has basic qualifications in junior and intermediate divisions, Geography and Primary division. John also has additional qualifications in Special Education (Part 1) and Math, Primary and Junior (Part 1). Currently, he is teaching Grade 6 Core (i.e., Language, Math, Social Studies, Science, Drama, and Physical Education) and identifies the types of learners in his class as ESL, ISSP/Individualized Education Plan (IEP), and behavioral students.

**Denise**

Denise is a Chinese-Canadian female, who has been teaching special education for 14 years. Prior to becoming a public elementary school teacher, she spent a year working as a French teacher in a Montessori school with special education learners (ADHD, ADD, and LD learners). Over the span of her career she taught summer school, ESL, special education resource
and behavioral classes in inner-city elementary schools in the GTA. She has basic qualifications in primary and junior division and has additional qualifications in Special Education (Part 1), The Slower Learner (basic), Reading (Specialist), and Computers in the Classroom (Specialist). For the past 12 years of her career she worked at a highly socio-culturally diverse school that is designated as a Model Schools for Inner Cities (MSIC) in the GTA. Denise identifies the various types of learners in her class as ESL/ELL, ethnically and religiously diverse, behavioral, and learning disabilities.

**Wyatt**

Wyatt is a White male of European origin who has approximately five years of teaching experience in Ontario. After attending university, Wyatt went overseas to teach ESL in Japan for five years before returning to Canada to pursue a teaching career. The first four years of his elementary teaching career was spent teaching in an inner-city school in the northwestern end of the GTA as a long-term occasional teacher (LTO). Specially, he taught Grade 3/4 Core to students who have academic and behavioural needs. He has basic qualifications in primary and junior divisions and no additional qualifications. Currently, Wyatt is teaching a split Grade 3/4 class in a primary school (K-5) located in the downtown GTA area. The school community may be described as ethno-socioculturally diverse, with a large population of immigrant families. He identifies the types of learners in his class as Home School Program (HSP) (i.e. special education) and gifted students.

5.2 Section Two: Understandings of Student Diversity and the Interrelationship Between Student’s Sociocultural Background and Science Education

During the last few decades science educational research discourse has placed increasing
emphasis on the scientific literacy development of socio-culturally diverse students (Carter, 2008; Lemke, 2001; Jegede & Aikenhead, 1999; Lee, 2003). Specifically, research shows that there is a growing concern for science educational systems to effectively address issues of equity and inclusion in science learning and teaching processes and practices (Lynch, 2000). According to Lee (2005b), science educators must consider how to create equitable learning opportunities and account for all differences amongst student populations (p.434). In this regard, my research study was concerned with examining elementary educators’ perspectives on student diversity issues in school science spaces in order to gain critical insight into how elementary educators account for socio-culturally diverse students’ access to science in the science classroom space.

5.2.1 Elementary Educators Perspectives on Teaching Science to Diverse Students

In my study, all of the elementary educators had differing understandings on student diversity issues and science education. Ben identifies cultural diversity or differences amongst students in his classroom as creating a diverse classroom space for scientific learning. He states the following:

I understand diversity to be those elements of the student population that demonstrate differentiation. How is a subgroup different from another? When you look at a class of twenty-five or twenty-six students they belong to the same class and same school and they are around the same age group but there are other things that come into play that make them different. The homes they are coming from, their family background, and the languages that they speak. Although, they might be speaking a common language at school, in a student population like my school, we know that we have immigrant families. So, student diversity would be the sum total of factors that differentiate one child or group of students from the other. What is my opinion on student diversity issues in science education? It would include things like the language and the vocabulary. What does the child speak and what is expected in the classroom? If there is a student from a different background how much of the scientific vocabulary that I am using would be familiar to him or her and would it be consistent with what he or she is experienced with. How would it fit into his or her prior knowledge, particularly if this child were joining our student population midstream? This is a middle school,
so where did the child go to school before coming here? How does the child experiences fit into the Canadian experiences? For example, in science we have an expectation, curriculum expectations and usually an example or two is given but those are not exhaustive. So, as a teacher I may be depending on those exemplars that are provided but I have to have awareness as to what extent those examples fit into the experiences of my students and who may not have had the foundational experiences in a Canadian context.

Ben acknowledges that in his classroom space there are culturally diverse students who have lived experiences and prior knowledge that differ from the mainstream school culture, which impact these students’ access to science. Specifically, he critically reflects on how school scientific language (i.e. vocabulary, concepts) can create barriers/challenges for students of varying linguistic backgrounds, especially students from immigrant backgrounds. Moreover, Ben is aware of his role as a science educator in facilitating the cultural transition of diverse students into the school science space and the shortcomings of the science curriculum in addressing cultural diversity in science education.

Steve focuses on students’ social class as a factor that creates differences in students’ science educational experiences. Specifically, he discusses the social inequities that exist within different school cultures. Steve states the following,

During the course of my teaching career I have seen both types of schools the “haves and have-nots” and I was lucky in both cases. If you are teaching at a “have school” only then you don’t know what the other school is like and you don’t know how lucky you are. You just think that all schools are getting the same resource and support that you do. In Mississauga, I taught at a school in a high social class area where the students are extremely motivated to succeed in school and the parents are the main reason for that. The parents are interested in what their child is learning and how the teacher is going to achieve success with their child. You as the teacher are expected to provide an enriching experience for those kids. As a school they get the funds to buy those resources so that the teachers can use them to provide students with success. When I moved from Mississauga to Malton I was at a school at the opposite end of the spectrum. The school was not in a very safe neighbourhood and the kids are struggling because both parents have to work. Also, other social issues, such as they are not living with their parent(s) or they could be living with older siblings, aunts or uncles. So these kids do not have the structure that the kids in Mississauga have and they
don’t get those same opportunities. The school was an extremely old school and it was converted from a high school into a middle school and their facilities and resources, especially in the science program, were substandard. At the school in Malton you’re basically trying to teach the kids to survive, let alone get an education. It was pretty difficult especially in that area because the kids don’t see that they have a unique opportunity to improve themselves and give themselves a chance to better their lives by getting an education. However, if you don’t have the resources you are already at a disadvantage compared to a kid in the southern end of Mississauga where they get everything that they need, such as support from family and school… I tried to help as much as I could with the resources that were available to me and I used my own money in order to give them an enriching experience that they can take with them as they left school. However, if it’s only one or two people do that and care about educating these kids in all subjects then it’s kind of hard to give them that opportunity to show what they can do, especially when you’re a “have-not”.

According to Steve there is a relationship that exists between students’ social class and scientific academic achievement. It has been Steve’s observation that schools comprised of students of a higher social class tend to have the resources, funding, and parental and community involvement necessary for developing effective science programs. However, this is not the case for students from lower social class backgrounds who attend high-poverty schools where there is a lack of resources, funding, and parental and community involvement. Steve contends that differences in the social class dynamics of schools create different scientific academic experiences for students. Consequently, at his school, Steve uses his own resources (e.g., financial) to support his science program and attempts to provide meaningful science learning experiences for disadvantaged students in his classroom.

Also, Denise claims that students belonging to a lower social class are at a disadvantage in science classroom spaces compared to students from a higher social class. She states the following:

Also, there is the assumption that all students have access to resources to do things like further research on their science projects and also that they have the ability to inquire. I mean lets not kid ourselves, schools that in higher income or affluent neighbourhoods, these students either have a superb support for
struggling kids or the struggling kids don’t go there… The challenge is that inner-city schools tend not to have the resources needed to advance their science understanding the same way as Rosedale students. In my school we have broken balances that don’t work, I mean three balances in the whole school and they don’t work half the time. When we are working with science kits that have to be shared amongst the whole school and they are not always kept up to date. For me I want resources that are hands-on and a lot of times I find that out of my own pocket I am buying resources to provide for my kids that are easy accessible in more affluent neighbourhood schools because the parent-community fundraisers or provides those resources monetarily or it’s through donation of resources or parents are the resource. We don’t have those resources and we don’t have human and physical resources. Even though for the X schools that are inner city we are now called inner-city model schools and we get extra funding and the principal can decide where that funding goes for schools that are inner model city. It doesn’t always go to science in fact science is rarely a consideration it goes to arts-based, language or literacy-based, and providing experiences, which I think are valuable, but no one is going to consider that we need scales, science equipment, and microscopes. We need stuff so that the kids can learn in science, so that’s a big issue.

Denise claims that the schooling experiences of students living in an affluent or higher income neighbourhoods are significantly different from students who are living in poverty. Denise works in an inner-city school where there is a limited supply or inadequate amount of scientific resources (e.g., human and physical) to effectively develop a science program. As a result, she has to use her own money to purchase resources for her science program. Moreover, Denise, highlights the fact that her school is a designated as an “inner-city model” school, which means that the school receives extra funding/resources for programs. However, there is a lack of school support (i.e., administration) for science education programming. Denise’s statements suggest that there is an inequitable distribution of scientific resources amongst schools, which creates differences in academic achievement amongst majority and minority students.

Moreover, Wyatt makes the connection that students’ social classes affect their scientific knowledge, and or experiences, he states:

A lot of kids in the Jane and Finch area don’t have the background knowledge or sort of experience to generate any interest in the subject. My observation is based
on the fact that these students come from a low socioeconomic status. So, these students go into science completely blind whereas you might have one or two kids whose parents take them to the ROM or Science Center which places them at an advantage over the kids who never left their house or went to the library or who never did anything.

Wyatt’s comments are based on his teaching experience in lower socioeconomic school communities, where students are at a disadvantage because of their limited knowledge/experience with Western Modern Science. Students who have the opportunity to learn about science outside of school acquire scientific knowledge or capital that gives them an educational advantage in school spaces.

William highlights the lack of qualified elementary educators teaching science and the Eurocentric nature of the science curriculum as key student diversity issues in science education. He states the following:

Well for one, you have teachers in the school system that don’t know or understand things in science. So, they can’t reach those kids that might have language barriers. I mean your level of explanation to those types of children is somewhat limited. For example, you have a kid who just came to the country and who probably knows a lot about science, electricity, and space and who is curious. However, if you can’t deliver your science instruction in a different way, other than the way that you’re comfortable with, then you are not going to reach that student. This is a big problem…so being qualified is one thing and that’s great but also you should have an arsenal of different ways of reaching children. We all know that kids learn differently and at different rates and because of such you need to strengthen your talents or tools when teaching children. So, having qualified teachers definitely would be a big plus to addressing student diversity issues in science education. Another concern I have is that the government or curriculum is like an umbrella, meaning that it will cover people but not everyone. I feel a lot of kids are left out. So, by having an umbrella approach to science doesn’t really help because you will have kids that will get it and they will fit under the umbrella, but what about the students that do not fit under the umbrella. There are a lot of things that get missed and I think the government needs to go back and look at the curriculum. The curriculum having ‘sciences for all’ doesn’t work because we can go back to the issues of socioeconomic problems, language barriers, and immigrant students they don’t fit under the Eurocentric umbrella of the current curriculum.

William, calls attention to the lack of qualified elementary educators trained to teach science to
socio-culturally diverse students. He suggests that teachers need to be knowledgeable about science content and the sociocultural backgrounds of students in order to effectively develop the scientific literacy of students who have varying backgrounds or identities. According to William, this can be achieved by adopting different pedagogical practices. He claims that school science is Eurocentric in nature, where minority students' experiences are excluded from science curriculum, which creates inequity amongst students. Denise, also, shares William’s perspective on the Eurocentric nature of science education. She states the following:

Ok, well student diversity to me is diversity in cultural backgrounds, religious backgrounds, gender, socioeconomic, and experiences. One of the issues is that science education is too Eurocentric in its approach. The concepts of how the world works is universal but the approach of how it is learned is Eurocentric. Recognizing that students come from many different cultural backgrounds and how as a culture they learn and see the world and how the world works should be acknowledged from their perspective.

Denise views student diversity as encompassing several sociocultural factors, such as culture, religion, gender, and social class. However, it is the Eurocentric nature of science education that does not account for students’ diverse perspectives/experiences in science learning processes.

Annie feels that students’ should be given opportunities to connect their cultural backgrounds, experiences, and perspectives to science learning. She states the following:

So, in terms of student diversity and science education: a) understanding where our students are coming from and their background knowledge; b) what are their interests; and c) what are their learning styles. That is big, that is huge, because we don’t really think about it, we don’t really think about our students interests and how this can drive our instructional practices. I have a student in my class that is really into Physics and Albert Einstein, so how can I connect his interests to what we are doing in the classroom.

Annie’s statement suggests that school science needs to be more student centered, where educators should adopt pedagogical practices that are reflective of the students’ diverse experiences. She considers the interests of her students in her instructional practices by making
connections their interest to science learning.

On the other hand, Helen discusses student diversity in the context of gender issues in science education, specifically, the differences in scientific achievement between females and males in the school science space. Helen states the following:

I find that in science a lot of the diversity issues come in the form of boys versus girls, where the boys are really engaged in a lot of the science activities, where sometimes the girls are not so much. I think it’s important to engage both boys and girls in science. So, using different types of activities and differentiating the instruction so that were not always doing hands-on activities, reading out of the textbook, having a discussion, or watching a movie. I think having different formats presented to the students. I think that is really important for students as far as thinking about diversity in terms of trying to include males and females in different areas and have them engaged.

Helen suggests that there exists a relationship between gender and student engagement in science, in particular males and females learn science differently. As a result, Helen adopts various instructional practices, which she feels allows for both males and females to actively participate in the science classroom space.

The elementary educators in the study share similar perspectives on the interrelationship between student diversity and science education. Specifically, the educators’ cite examples of how multiple social variables, such as culture, class, religion, gender, language, and learning abilities, can affect students’ scientific literacy development. Moreover, several of the educators connected student diversity to science pedagogical practices (i.e., teaching and learning) and highlighted the need for educators to address students’ backgrounds, interests, prior knowledge and experiences in science practices and processes. Moreover, the educators suggested that the nature of school science culture creates barriers for diverse learners. However, none of the elementary educators considered the use of alternative forms of scientific knowledge found in current science educational discourse, to address minority/marginalized students’ scientific
literacy development.

Over the past decade there has been a considerable amount of science research on various sociocultural perspectives of science education (Carter, 2008; Lee 2003), which challenges traditional science educational models (i.e., WMS). Several scholars contend that there are other models of scientific knowledge that effectively addresses the needs of minority students. Sociocultural perspectives on science education are significant because they interrogate the nature of science education (i.e., Western based theories) and propose forms of scientific knowledge that account for the changing dynamics of school culture (Aikenhead, 2006; Calabrese-Barton, 2001a; Hodson, 1993; Hodson, 2002a; King & Ritchie, 2011; Lee & Fradd, 1998; Roth & Calabrese-Barton, 2004). Carter (2008) states the following: “[s]cience studies have challenged Western science’s traditional claims to be value free, objective, and universal truth, revealing instead the sociocultural construction of scientific knowledge, and its coexistence with other various and multiple local/indigenous versions of science” (p.165). The eight elementary educators’ are aware of the various social variables that can affect students’ science learning experiences. However, they do not necessarily consider how the Western science educational model, as a whole, reproduces systemic inequities and barriers for minority students. Consequently, educators must move beyond simple or narrow understandings of student diversity issues to understand how these issues can be reproduced in science education and begin to deconstruct how dominant school science culture can be hostile spaces for diverse learners. I suggest the need for elementary educators in general to critically reflect on their own epistemological understandings about science education, in particular scientific knowledge, in order to determine if their understandings respond to the sociocultural needs of diverse learners. Of course, the eight elementary educators are expected to teach the science curriculum
expectations as outlined by the Ontario Ministry of Education. However, there is no official ‘pedagogical lens’ (or framework) that educators must adopt in science classroom spaces. Consequently, educators can frame science curriculum expectations and practices and processes (i.e., teaching and learning) around sociocultural perspectives. As a result, it is important for elementary educators in general to extend their understandings about student diversity and science education to include understandings of sociocultural theoretical/epistemological frameworks of science education to effectively address the multiple social variables that affect student scientific literacy development.

All of the eight elementary educators work in science classroom settings comprised of diverse students. However, not all of them include their students’ sociocultural background into science education processes (i.e., teaching and learning). Lemke (2001) defines a sociocultural perspective of science education as integrating science teaching that is responsive to students’ different needs and with teaching that addresses the challenges of a heterogeneous and diverse classroom community. John and Helen are Grade Six teachers who do not consciously or actively consider students sociocultural backgrounds in science classroom spaces. John states:

I do not necessarily include my students’ sociocultural background, like their gender, race, and social class, into my science program. I haven’t seen students be negatively impacted by these things this year. A lot of the science that we do with Space, Flight and Electricity is pretty basic. I start from the beginning where there is a lot of stuff that I explain with the thinking that the students don’t have a lot of knowledge on this in the first place, so I am not assuming that they know a lot of this stuff anyways. I can see if some student in a higher social class has parents who could take them to Flight museums where they would learn about airplanes, but for ninety nine percent of students I think they are going to start at a relatively same place for a lot of the Grade 6 curriculum. The only unit that students might have more knowledge than others could possibly be the Biodiversity unit where in that unit there are some things that I assume some students know already at this point in their life which others might not know. That would be one unit that I would potentially have to look at these things more and take into consideration the different qualities of students.
In his class, John focuses on differences in students’ scientific knowledge and not necessarily on student’s diverse sociocultural background. According to him, the students’ sociocultural backgrounds do not necessarily impact their sociocultural background.

Helen states:

I don’t think you have to include students’ sociocultural background. You just have to do what’s best for all the students. So, I don’t necessarily think about students’ race, gender, and social class but instead I think what’s best for all the students in the class. I don’t necessarily say this student is lower social class or higher class…I don’t think about it like that. I think about what is best for these students and what can we do to help them learn the best. So I use a lot of differentiated instructional practices in my class. For example, some students don’t have a computer at home and there is a lack of computers at school, so you can’t say to the students that they have to do a science PowerPoint presentation. I always give them a choice on how they are going to present their work. They can make a poster, booklet, or Prezi, so I give them that choice. We also have netbooks at our school so we have more access to technology, which is really great. Also, I use diverse groupings when it comes to assignments or group work so my students get different perspectives. I probably would not have a group of all boys or girls I would change it up and have bunch of kids from different backgrounds, races, genders, and social classes in a group. So, you get a balanced look at some of the different perspectives when they are working on a science assignment in a group.

According to Helen she does not consciously consider her students’ sociocultural background in science educational processes instead she does what is best for the students, collectively. She uses differentiated instructional practices, such as use of technology and provides her students with choice. In addition, she uses diverse groupings to allow diverse students to work together and share their own experiences and perspectives. Helen’s perspective reflects a universalistic perspective of scientific literacy development (Siegel, 2002). Even though she is aware of her students’ differences and encourages them to work together in the classroom space she does not actively address or include students sociocultural backgrounds into her scientific pedagogical practices.

In contrast, all of the other educators shared their perspectives on how they include
students’ sociocultural background into science educational processes.

Both Denise and William consider the gender and cultural backgrounds of their students in the science classroom. She states the following:

I take into consideration gender and culture because I have predominantly Muslim girls in my class. So, let’s start with gender, I am sure that you can show me science studies that show that the interest of girls in science tends to drop at an early age. Like mathematics, you don’t see in the media a lot of news about female scientists. So I like to encourage my girls to have an interest in science and engage them in science learning in order to feel a sense of confidence. I don’t know if that’s because girls at a very early age they are taught to be submissive and not to challenge things. I might be generalizing but girls tend to be more accepting of things and they don’t really challenge things. I think statistics shows that girls don’t have the same engagement in science and math as boys do. So I often try to really focus on engaging girls and pushing them to think. Even to the point where sometimes when my students are working a group I will point to a girl and have her start the inquiry or discussion in very subtle ways but clearly getting the girls to start it off opposed to the boy. We talk about history or scientific history and I bring in a lot of female role models, such as Roberta Bondar. We discuss how females have made successes and contributions to the scientific community. Also I try to keep it relevant, a lot of my girls say I want to be doctors and I ask them, what do doctors do? So I show them people who made advancements in the scientific/medical community and they are females. In terms of culture, I try to bring in the success of other cultures. Like I was saying before a lot of the scientific knowledge during the Middle Ages came from the Middle Eastern community and the Islamic community, so I try to make those connections, so science is not so Eurocentric. It’s like look at these Islamic and Arabic communities who have made discoveries in math and science.

In her classroom, Denise actively seeks the participation of her visible minority female students in science learning processes (i.e., experiments and discussions). Specifically, she encourages her female students to be critical thinkers by challenging dominant notions about science and stereotypes about female participation in science. Her objective is to increase her females students’ participation in science learning and develop their confidence and engagement in the classroom space. Moreover, Denise makes references to other cultures contribution to science knowledge in order to challenge the hegemony of Eurocentric views in school science.

William states the following,
It can be a challenge at times to include students’ sociocultural background into science because you can’t rely solely on school resources to get kids from different sociocultural or economic backgrounds engaged into the things that you are teaching in science. What I try to do is to look at the socioeconomic makeup of the classroom and provide materials that meet the needs of the students. I find that I put a lot of girls in leadership roles because females need to be in these positions in order to participate in class… The different types of learners also pose a problem in the classroom, so you have to get those kids included in whatever you teach. You can’t have them feeling left out because once you have them feeling left out they start to act out and they don’t respond because they are not engaged. I find that hands on activities work for most children of varying backgrounds, where they are given things to manipulate. A lot of them may not feel comfortable in discussing what they have found so instead you might get them to write it out or draw picture so you can see it. For kids who are visible minorities, how I include them in science is I have this chart that has inventions that are invented by people that you would rarely think of. I give each child a sheet and they look at the list of inventions made by visible minorities and a lot of them are shocked. Afterwards, I ask them to pick a name and what they invented then research the inventor and write a brief paragraph and share their learning to the classroom. After getting them hooked through research then they are able see the faces of these individuals, for example, George Washington Carver or Ben Carson the Black surgeon. Like, they need to see that and they need to see themselves in that light.

William finds it a challenge at times to include students’ sociocultural background into science learning processes because of limited school resources. Nonetheless, he acknowledges students’ socioeconomic differences, in particular gender and cultural differences. Specifically, he encourages his female students to actively engage in science learning and uses culturally sensitive materials to engage his visible minority science learners.

Similar to that of Denise and Wyatt, Ben calls attention to students’ cultural experiences in science learning processes. He states the following:

Personal research is one strategy that I use, in terms of reading books, using the Internet, asking questions. For example, if I know a child is from the Caribbean, South Asia, or Europe and does not have the foundation or elements of science education in a Canadian society. I think it is part of my responsibility to do research. For example, I teach a science unit on Flight and I like to tap into my students’ personal experience. It gives me great pleasure not to just explore the curriculum but to go beyond it where I really look into something like a kite. I think the concept of a kite has a cultural component, which varies between
cultures, such as Canadian, West Indian, and South Asian cultures. Part of my responsibility as a professional is to do that personal research and to find out information. I have to do that on my part and I think I need to and I have to invite a sharing of knowledge. Here is what I know, what do you know? It will give any teacher great pleasure to hear from the student and it gives the child an opportunity to share his or her knowledge that may be specific and unique depending on where he or she is coming from. So, call attention to what might be different in terms of what the child has to offer. I use the flight example where the students get the opportunity to make a model of something that flies. A child who is coming from a different background outside of Canada brings in a special kind of kite. So, you call attention to it because this is new to us and it’s a learning experience for us living in a Canadian context. We are familiar with kites but lets see what is similar and what is different. This creates a real good learning opportunity for the whole entire class because we can all get to see the differences.

Ben makes it his responsibility to seek information (i.e., research) about his students’ cultural backgrounds and integrate their experiences into science learning processes. Furthermore, he encourages his students to share their knowledge (i.e., experiences/backgrounds) about scientific concepts, in their own sociocultural context, in order to create new science learning opportunities.

Annie states the following,

Hmmmm…that is a good question. I do not think I include enough of my students’ background …Umm, in terms of my ESL students, I could do more in finding out what they know about science… So, I think about possible language barriers and even those kids that who may not be able to write their ideas down they can do it orally. It’s very interesting the girls in my classroom, I think they are equally interested in science as the boys. So I am not really sure…but I know that lately I feel like as I get older my race, gender, age, and even my social status comes more into play in how the way people treat me or how I fit in. I think when I was growing up, I was like whatever, I am a visible minority but it does not affect me. Also, in my classroom I have noticed the different ways the boys treat the girls in my classroom because one day there was a conversation between the boys and girls in my classroom and one boy in my classroom was calling a girl “woman” and the girl was okay with that. However, I was like, “no, we don’t call anyone woman. We address each other by our names”. Then I told my female students that because they are females they will have to probably work harder than their male classmates to be successful and if you are a girl of a different ethnicity, you maybe treated differently. It doesn’t mean that you are not going to succeed as a girl but there are barriers. As a teacher myself I see those obstacles more, they are
more defined and clearer.

Annie feels as if she does not do enough to include students’ sociocultural background in her science classroom. However, she does consider the science experiences of her ESL students and possible language barriers in science. In terms of gender, Annie claims that the male and female students are equally engaged in science learning, however, she is critically aware of gender biases that may exist in society which can be reproduced in the classroom space. As a result, she encourages her students to think critically about their own personal identities and how it can create barriers to their success.

On the other hand, Steve actively addresses gender issue in his science practices, he states:

Well for me, I don’t include all of my students’ sociocultural background. Instead I focus on male-female issues because the males are usually not strong readers. So, it’s hard for males to apply the skills that they have into other subject areas, such as science. So, if you’re learning a new concept in class and you are expected to research a topic on your own usually through a textbook then it’s difficult for males. It has been my experience that females in middle school and in high school tend to be the stronger students. There has to be some way to get it close to 50/50 as possible where you have the males and females just as interested in science and the opportunities they get in science… So I really I haven’t come across many problems, other than the male-female issue. I think that’s the one that is more evident when teaching a class in science. Maybe not so much a race issue but more a gender issue.

Steve is only concerned with addressing the participation of his male students in his science classroom. It is his perception that only male students are experiencing difficulty acquiring scientific learning and so therefore he addresses gender rather than race related issues in his science classroom.

Wyatt is primarily concerned with social class issues and differences in students’ scientific knowledge. He states:
Race and gender are not necessarily issues at my school, but social class is where I think the divide lies… I don’t know for lack of a better term poor people just don’t have the same exposure to things that affluent people do, so that would be where you want to hit the base line. So at the beginning of any unit you might want to do the world famous KWL chart to see what sort of stuff your kids know and what sort of stuff they want to know and get a basic handle on what their understanding of the subject is. So I can determine if I need to start at square one or move a little ahead or go further back. So, if the student has little understanding of the science concepts, you have tools and books to help them catch up. So, what I do is really figure out what the kids understand about science before I begin teaching.

Wyatt considers how students lived experiences and or social realities (e.g., social class status) may impact their understanding of school science knowledge. As a result, he is concerned with the prior scientific knowledge that the students have in his class and uses pedagogical practices that accounts for his students’ varying levels of scientific literacy levels.

Over the past couple of decades, current science educational reform policies have focused on equity issues and science education, in particular how to include students’ sociocultural backgrounds into science education (AAAS, 1990; Lee, 1999; Lynch, 2000). According to Lee (1999), “students from diverse languages and cultures bring to the science classroom ways of knowing and talking that are sometimes discontinuous with the practices of mainstream science” (p.480). As a result, science educational practitioners have to change their scientific pedagogical practices to meet the needs of diverse learners (Lynch, 2000). In 2007, the Ontario Ministry of Education revised the elementary science curriculum document to incorporate principles of equity. The Ministry states that science programs should be “inclusive and reflect the diversity of the student population and the population of the province” (p.11). This would suggest that elementary science educators are to be actively and consciously utilizing science practices that acknowledge students socio-culturally diversity in science practices. There is a considerable amount of science educational research that shows that including students’ sociocultural
background in science education is necessary for meaningful scientific literacy development (Lynch 2000). Specifically, the Ministry revised the curriculum to include sociocultural references (e.g., Aboriginals) in the specific expectations and planning program considerations that highlight areas of concern in science programming, such as instruction, antidiscrimination, ESL/ELL learners.

The elementary educators that considered students’ sociocultural backgrounds in science learning had identified various sociocultural variables (i.e., gender, race, ethnicity, language, and social class) that they perceive as impacting students’ scientific literacy development. Overall, the educators used various strategies to include or address students’ sociocultural background into science educational processes (i.e. teaching and learning) such as differentiated instructional practices, scientific – inquiry based activities (i.e., hands on experiments), critical thinking/literacy-based activities, and culturally relevant materials. Villegas and Lucas (2002) discuss the importance of educators expanding their “sociocultural consciousness”, in the context of student diversity. The scholars define sociocultural consciousness as, “an understanding that people’s ways of thinking, behaving, and being are deeply influenced by such factors as race/ethnicity, social class, and language…Without this insight, teachers are unable to cross the sociocultural boundaries that separate too many of them from their students” (p. 22). In my study, the educators had their own perspective on the interrelationship between students’ sociocultural background and science education. Specifically, the educators consciously selected sociocultural variables that they perceived as being relevant to students’ scientific access to science and therefore excluded other variables (e.g., race, religion) in their science educational practices and processes. This may suggest that the elementary educators may not understand the complexity in addressing the various sociocultural contexts of science education.
Intersectionality refers to an “analysis claiming that systems of race, social class, gender, sexuality, ethnicity, nation, and age form mutually constructing features of social organization” (Collins, 2000, p. 299). In the classroom space, there are multiple forms of oppression that create barriers for students, in particular minority students. As a result, it becomes important for science educators to be aware of how social markers of differences intersect and reproduce social inequities and power imbalances in the science classroom space.

Elementary educators to interrogate their own notions about diverse students’ sociocultural background. Villegas and Lucas (2002) identify two key ideas that educators must consider in order to be socio-culturally responsive in science educational processes: first, educators should examine or explore their own sociocultural groups to which they belong in order to reflect on how this may impact their own understandings of students backgrounds and the sociocultural contexts of science. Second, educators need to recognize the complex connections between schools and society. Specifically, educational systems can reproduce and legitimize social inequities and systemic discrimination that affects disadvantaged sociocultural groups. As a result, it becomes imperative that educators are conscious of how schools privilege and empower specific groups (i.e., mainstream students) creating differences in scientific academic achievement. Diane Gérin-Lajoie (2008) states the issue of taking a ‘colour-blindness’ approach to student diversity issues, she writes the following:

For example it is not uncommon to hear teachers mention that their students are all the same: simply children. This discourse does not acknowledge the impact of race and ethnicity on the students’ lived experiences in schools as well as outside of the school… Often, teachers are colour-blind and see the challenges of these students as individual ones, not the result of a more systemic process of exclusion. (p.11)

Hence the need for elementary educators to have a clear understanding of science educational reform policies in the area of equity and inclusion, in particular the role of the educator in
addressing students sociocultural background in science learning and teaching. Lynch (2000) acknowledges that science educators’ beliefs and pedagogical practices must reflect science education reform policies on equity in order for systematic change to occur in science educational institutions. The variations in the elementary educators’ perspectives on how to include students’ sociocultural backgrounds highlight the need for concrete and or shared understandings of the sociocultural contexts of science. Even though the elementary educators have a sense of sociocultural consciousness, it is not clear if they understand the complexity (i.e., intersectionality) in addressing sociocultural contexts of science education.

5.2.2 Elementary Educators Understandings of Official Discourses on Student Diversity and Science Education

As explained in Chapter 4, the Ontario Ministry of Education revised the elementary science curriculum to include a section on program planning considerations section, which highlights important areas (e.g., instructional, cross-curricular, English learners, critical thinking and critical literacy) in science education, which affect students’ access to science. In the context of student diversity, most notably is the “antidiscrimination education science and technology program”, which outlines for educators how to recognize and address students’ diversity in science educational processes and pedagogical practices. It is a Ministry expectation that educators are expected to consider use the principles and strategies as outlined in the section of the document to ensure ‘science educational equity’ for all students. In my study, all of the elementary educators, except for Ben were unaware of the program planning considerations section in the Ontario Ministry Science and Technology curriculum. Ben stated the following about the science program planning considerations:

The program planning considerations are good guidelines. It reminds me that as
teacher I have to take into consideration the child’s prior knowledge. You want to start off with what they know and move on to what they don’t know. So, in terms of differentiated instructional approaches for something like a Science and Technology curriculum, you would have to keep safety in mind. What are the things that the students need to know as they do a unit, let’s say on electricity? So what are some of the safety concerns surrounding electricity, working with batteries, and learning about how electricity travels. Does the students already have the knowledge and skill? Or will you have to provide that as part of the learning experience? Teachers must have an awareness of cross-curricular opportunities in presenting your science curriculum. I think the Ministry is encouraging teachers to present science in a broader context, in terms of showing connections with the other subject areas. Things like special education, environmental education, and one of the considerations is antidiscrimination education, so these are good reminders to the science teacher when developing his or her program.

Moreover, Ben discusses how he uses the program planning considerations in his science program. He states the following:

A number of them fall into place. For example, the topic of safety is in the curriculum. So both in my content and practice and I would cover safety issues specific to the unit that is being studied. The unit of study will determine what types of instructional approaches I will use, including things like the type of assignments given, how the students work on unit tasks, that is whether it’s individual, in pairs or group, guided instruction, modeling, and independent learning. I rely heavily on the role of technology and how that impacts the science curriculum. Also, how I can use the library to support my science program and lessons. I have seen our librarian do a fantastic job partnering with classroom teachers to help students develop research skills. She has a specific research model that she uses with the students both for science and social studies. Literacy and numeracy in science technology is another important consideration that comes really handy in tying science learning with math, if you challenge your students. I can cite an example of one of the units that I had a significant measure of success with and that I was really happy with. The unit was electricity and I challenged the kids to build a model car. So, you combine the students doing research on the type of car or futuristic car and pull that all together to make an electric car with an awareness of energy issues and stuff like that. They had to tap into what they had learned throughout the unit from content related to electricity and safety measures because you are working with wires and batteries. Also, tying in math where the students had to make a car that can travel a certain distance and they measure along the way the size of the car and how far it traveled. So, being able to facilitate cross-curricular learning and connections like that was fun. So, the program planning considerations are helpful in the sense that you may have some of those considerations in the back of your mind. The considerations can work as a checklist in determining what are some things that I have considered for
Ben uses the Ministry’s program planning considerations as a checklist. He provides examples of how he uses various instructional and cross-curricular (e.g., literacy and numeracy) approaches in his science programming.

Even though, the remaining elementary educators are unaware of the Ministry’s program planning considerations, some of them discussed reasons for their unawareness of the Ministry’s considerations.

William and Helen contend that the only key feature in the curriculum document is the grade level science expectations, as the expectations are used to construct their science programs.

William states the following:

I know most teachers when they get their curriculum document they go straight into the expectations, which is the primary focus of how I teach. Even in teachers college when you get examples of the curriculum document, I can remember the first time getting one, it was a math one, and we went straight into the Grade 7 expectation for surface area. So, I specifically look at the expectations for the year, the Big Ideas, and the types of activities that I want my kids to do in class.

Helen states:

I am not really sure what the program planning considerations are in the curriculum document. I know that when I use the curriculum document I basically go to the topics that I am teaching which is the Grade 6 topics (Electricity, Flight, Biodiversity and Space) and I take a look at those curriculum expectation and decided what I want my kids to know. So I take a look at what’s going to be my end task and what do I want my kids to know. I might look at some of the Peel documents on the Big Ideas and that kind of thing to help me backwards plan. Now I have done it for quite a few years so I have a pretty good understanding of the expectations in the curriculum documents. I always refer to them in my plan book and I always have the curriculum documents there for reference and I always check them to see what I need to do… As far as the curriculum goes I know that we actually have to implement the actual expectations and that is why I spend my time focusing on. I never really had anyone say I have to read the program planning considerations and we haven’t really had any discussion about it. It’s never been something that people said we had to do. I know that in our classroom I try my very best to ensure that I include all my students we are considering their needs, backgrounds, and their uniqueness.
Both William’s and Helen’s primary use of the science curriculum is to retrieve the grade level expectations, as the expectations provide them with the ideas (i.e., examples) and activities that they will use in their programming. Moreover, Helen claims that she has never been specifically directed by school personnel to use these considerations in her science programming.

Wyatt states:

To be perfectly honest I am not aware the program planning considerations. You know what at the risk of sounding like a bad teacher I am going to give you a window into how I approach the curriculum. So next year, I have a Grade 3 class and I am going to take a look at the curriculum but what I am going to do is I am going onto the website or the text and I am just going to go to the Grade 3 section. I am not going to read page one of the curriculum like it’s a chapter book. I am going to go straight to the stuff that I need to do in order for me to teach and that is the reality of the situation. It’s a time management strategy, I have a finite amount of time to plan for it and I have a finite amount of time I have to deliver it. So my consideration first and foremost is delivering the curriculum as I am obligated to do. This is the stuff that I report on and that you know when I talk to parents and my principal and colleagues the stuff that were are actually talking about. I am just going to say, I haven’t done a poll or anything, but I don’t think anyone reads the first part of the curriculum they just go to the sections that pertain to the information that they need.

Wyatt claims that he has a limited amount of time to deliver his program, and as a result, his primary focus is on delivering the science expectations as he is expected to report on students’ scientific academic achievement of the expectations.

Denise calls attention to the fact that the program planning considerations are only considerations and therefore not necessarily of primary concern for her when developing a science program. She states:

I am not entirely convinced that every single teacher reads the science curriculum. I don’t necessarily put the curriculum document by my bedside and go through all of that. It’s repetitive like every single document is going to say the same thing except for the only thing that is going to change is the subject label. It’s wordy and teachers gets such a huge influx of text documents that they have to go through that after awhile it becomes part of a pile we have to focus on getting the job done. So yeah, I am guessing it’s the suggestions that you can do to make
your students more successful in science learning. It’s a consideration, it’s not mandated and then because it’s a consideration we don’t have time to consider it. We only have time to consider what we have to do in the expectations and so at the end of the day you are relying on good teachers where the considerations and planning are embedded in the program as a good science teacher.

The aforementioned elementary educators suggest that the primary use of the curriculum document is to provide educators with the grade level science expectations. As a result, the educators do not necessarily consider all of the contents in the science curriculum because their primary focus is on delivering the grade level science expectations.

On the other hand, Annie is aware that the curriculum has been revised and recognizes that she should have knowledge about the program planning considerations in science. She states:

What are the program planning considerations? Umm, I haven’t read them but I am guessing they are areas that you need to have a focus on, in terms of delivering your science program whether it is… I guess when you’re planning you need to have time for exploration, maybe a time for assessment or student feedback. I don’t know I haven’t read it, that’s the part that’s horrible, I know the math and language in and out… but Science not so much. It’s good that the science curriculum is revised and I like it because it now includes the big ideas but I have not gone through page one to the end and I probably should. Right now the Ministry has some really good resources for literacy and math it’s called the, “Guide to Effective Instruction” in mathematics and language, they are amazing and they kind of need to do something for science. I really look into the curriculum guides because of those resources and what the Ministry offers you is actually pretty good. I haven’t had the initiative and the drive to look into the science curriculum but I should.

According to Annie, she has not had the opportunity to review the document in its entirety and suggests that the Ministry should create a separate document that focuses solely on effective instructional practices in science, similar to ones for math and language.

Overall, it cannot be assumed that the elementary educators are not already implementing the program considerations as outlined by the Ministry in the science and technology curriculum document (2007). Nonetheless, the elementary educators’ unawareness of the Ministry’s (2007)
science program-planning considerations suggests that within their school spaces educators are not actively receiving support on curricular changes in specific school subjects. Overall, there is a need to increase the level of educators’ awareness about curricular revisions to extend beyond the science content and or expectations.

In the context of student diversity issues and science education, in 2009 the Ministry implemented an equity and inclusive education strategy, which mandated all Ontario school boards to devise and implement equity and inclusive polices in local schools. The Ministry’s strategy was to revise all curriculum documents to address student diversity issues. Specifically, revise curriculum documents are to contain a section on antidiscrimination science education.

The Ministry (2009a) states the following about curriculum policy changes:

> The Ministry’s curriculum policy supports respect for and acceptance of diversity in Ontario’s schools. Through the curriculum review process, curriculum is continually revised to maintain and increase its relevance to the changing needs and lives of students. Recent revisions include the addition of sections on antidiscrimination education and Aboriginal perspectives and how they relate to the particular subject or discipline. (p.20)

Hence the notion of an antidiscrimination science and technology education, as outlined in the 2007 (revised) science and technology curriculum document.

However, since the antidiscrimination science and technology education is located in the program planning considerations section, none of the educators except for Ben had an understanding of the Ministry’s antidiscrimination science and technology program. He stated:

> Sometimes we set our plans and we have our program in mind and we don’t want to deviate too much from it. However, by its very nature antidiscrimination and an attempt to be inclusive, requires a readiness to accommodate novelty. That is something that is new, something that was not considered before, and something that may be very apparent in our school setting but it may not be so apparent somewhere else. So, for students coming from that somewhere else, in order to be inclusive and antidiscriminatory it would mean being open minded enough to be receptive to that new idea or that different way of thinking. I think the only barrier to that is sometimes you may not being aware and I think part of that
antidiscriminatory process is to just emphasize an openness and readiness to explore what might be different or to welcome what might be different.

Ben discusses the notion of inclusion and the importance for educators to have an open mind to students’ difference and to create a science classroom environment that reflects or accepts these differences.

Even though the elementary educators were unaware of the aforementioned program they were able to describe their own perspectives of what an antidiscrimination science and technology program would include in a science classroom. Steve, Annie, Helen, and William discussed the notion of equality in their understandings of an antidiscrimination science and technology education. Steve states the following:

Okay, antidiscrimination in the science classroom would include creating a program where that nobody is left out and where everyone has the same opportunity to learn in the science class, regardless of their gender, race, and social background. It has to be equal for all and that is basically my understanding and it would be up to the teacher to ensure that it happens.

Annie states:

I guess an antidiscrimination science program would mean providing an equal opportunity for all students to learn science especially students with special needs or language barriers. Also, that we’re not giving them less of the curriculum because of those needs and that’s a big one for me in the classroom. I think there are days, not even just in science but other areas, where I feel that I am not giving them enough because of those language needs or because there is a communication barrier or a gap in terms of their learning skills. So how do I deliver a science program that is fair and equitable?

Helen states:

I really have never heard of that antidiscrimination science and technology program in the document. I really don’t know what that means. I know that when I do science planning I go straight to the curriculum expectations. Now an antidiscrimination program I assume would include something about treating all the kids equal in terms of meeting their needs academically, socially, racially, and gender. So I think that’s what antidiscrimination program would be but I am not familiar with that particular part of the document. It’s going to make me want to
go read it and figure out what it is but I really don’t know what it is. I could assume what it is but I really haven’t read it specifically to tell you what it is.

William states:

Well my understanding might be a little different from the science and technology curriculum, but I would say respecting my students’ voice, opinions and giving them that open floor to talk. I am going to have to back to look at the curriculum where this section is located and review it. Again, maybe my definition of antidiscrimination is different but I know for me antidiscrimination, especially in science, is students being able to give their own ideas, having an open mind to what the child is saying, having students being able to come up with conclusions, and writing reports and observations. It is pretty much having that ability to be or speak freely about a topic. Like I said, being different because everyone does things in a different way and it has to be accepted when the child proves it.

Even though the aforementioned educators are not conscious of the Ministry’s ideas about an antidiscrimination science and technology program, they understand that it is the responsibility of the educator to create a science classroom environment, where students regardless of sociocultural background or learning abilities receive equal opportunities to actively participate in the science classroom space.

Both Denise and Wyatt provide a critical perspective on the Ministry’s antidiscrimination science and technology program. Denise states the following:

I think it makes sense for an antidiscrimination science and technology program to be included in the curriculum if the Ontario Ministry of Education is trying to complement Board policies on inclusive and equitable education. However, it’s not in the right place in the document because no one reads it, but at the same time the fact that it has to be there tells me that the science curriculum may not be so inclusive and equitable to all students. It’s almost a reminder for educators because if we as teachers, parents, and administrators were already thinking this way then it wouldn’t need to be in the curriculum. It’s kind of like talking about anti-bullying campaigns, if there was no bullying then there would be no need for them. So, the fact that we have one kind of shows that bullying is an issue. So same thing with the antidiscrimination science and technology program, it’s there because there is an issue, so it should be up to the Ministry of Education to start providing education to the teachers. It’s like the Ministry is playing lip service, it’s probably found in every single document. It’s playing lip service and it’s just basically a checklist on a to do list, that the Ministry is being antidiscriminatory
and being equitable and inclusive. Like, with every other resource and program that is downloaded on teachers you don’t actually get the training or actual support.

Denise recognizes the importance of addressing antidiscriminatory issues, in the context of creating equitable and inclusive education models. However, it is her suggestion that the Ministry should be actively providing science educators with the education (i.e., training and support) on these issues.

Wyatt states,

I guess my understanding of an antidiscrimination science and technology program is nil. My question is why is there an antidiscrimination science and technology program? Is there a lot of discrimination going on in the science? I really don’t understand what it is first of all and why they would have it. What is this in response to? To be honest I think enthusiasm and love of science transcends any boundaries or barriers that the students come into class with. Anyone can get enthusiastic about the curriculum and the big thing wouldn’t be a science specific thing but maybe more of a Tribes sort of thing where you create that culture in your class. Everyone feels that they can participate and share their ideas without any sense of embarrassment shame or inadequacy and that’s something any good teacher does. You don’t want to isolate or exclude any particular students in any of the curriculum for any reason whether it’s their gender, race, social class, and sexual orientation. So I mean it goes beyond the science thing where you can’t compartmentalize this as a science only thing. Do you want to go a little deeper lets say a kid that comes into the class with the misconception that girls can’t do science then sure I am going to have that discussion with my students, but is this something that I need to address at the particular science unit? No. I think if the teacher has built it into their classroom on a regular basis then everyone will feel welcomed and encouraged to participate.

Wyatt is unaware of the reasons as to why there is a need for an antidiscrimination science and technology program. According to him, it is a general expectation that educators are on a regular basis providing all students in the classroom with opportunities to participate in learning processes, regardless of the subject discipline.

My findings suggest that the majority of the educators are not implementing science programs that are based on the Ministry’s ideologies about student diversity issues and science
education. All of the educators are conscious of students’ sociocultural backgrounds (e.g.,
etnicity, class, etc.) and are aware that it is the primary responsibility of the science educator to
create these inclusive classroom environments. However, except for Ben, the elementary
educators unawareness of the Ministry’s expectations, in regards to equity, inclusion, and student
diversity in science education, suggests that there is a lack of communication amongst key
educational stakeholders in school spaces. The Ontario Ministry of Education has proposed and
implemented critical epistemological changes to educational models in Ontario; however, some
educators are unaware of these changes. In the context of science education, it is clear that
elementary educators are not necessarily receiving support and training on how to effectively
implement the revisions to the science curriculum (i.e., program planning considerations) in their
programming. The majority of the eight elementary educators state that they use the curriculum
solely to obtain the grade level science expectations and do not necessarily consider the other
sections in the curriculum document. Hence, Annie and Denise suggested that the Ministry
should create a comprehensive and separate document that focuses solely on student diversity
issues, rather than place these issues in a minute section in the curriculum. Moreover, if these
program planning considerations, such as the antidiscrimination science and technology program
are important then teachers should receive the necessary support and training to acquire
knowledge about these issues.

Research shows that despite Western science educational reform, efforts in the area of
equity and inclusion, the underachievement of diverse students is still an issue (Van Garderen,
Hanuscin, Lee, & Kohn, 2012). Scholars identify variations in scientific pedagogical practices as
having a significant impact on students’ difference in scientific achievement (Brownell et al.,
2007; Posnanski, 2002). Consequently, the elementary educators’ lack of awareness of the
Ministry’s science program planning considerations may have an impact on students’ access to science, especially if the educators do not have a clear understanding of how to effectively address student diversity issues in teaching and learning practices. It cannot be assumed that all elementary educators are actively implementing antidiscrimination science and technology programs, as outlined in the curriculum document, especially when they have not received any school support or guidance on how to do so effectively.
Chapter Six: Obstacles in Teaching Elementary School Science

Chapter Six is about the obstacles faced by the participants in teaching elementary school science. In the first section, I critically examine teacher accountability issues in science education. Specifically, limiting factors, such as provincial standardized testing and lack of time and scientific resources, which affect educators’ ability to respond adequately to student diversity issues in science education. In the second section of the chapter, I discuss professional development support for elementary educators teaching diverse students.

6.1 Teacher Accountability and Science Education

According to science education literature, the notion of accountability plays a role in the science educational outcomes of diverse students. Lee & Luyk (2006) cite research findings to state the following, “when science is not part of accountability measures it is taught minimally in the elementary grades” (p.134). Scholars claim that elementary schools with large socio-culturally diverse student populations tend to focus primarily on developing students’ basic skills in literacy and numeracy rather than science (Lee, Deaktor, Hart, Cuevas, & Enders, 2005). Moreover, state emphasis on standardized large-scale assessment in numeracy and literacy in schools affect educators’ scientific pedagogical practices (Forman & Sink, 2006). As a result, socio-transformation of science educational systems, in the context of equity, inclusion, and diversity issues in education is not at the center of school science discourse. Gérin-Lajoie (2008) states that, “[in] an era where accountability is at the center of the school personnel’s preoccupations, issues of equity are often put on the back burner” (p.9). Furthermore, there are several other factors or issues that may impact elementary educators’ ability to effectively develop equitable and inclusive science educational models in their classroom space.
All of the eight elementary science educators identified provincial standardized testing, such as Education Quality and Accountability Office (EQAO) as affecting their science program delivery. The elementary educators in the study teach Grade 3 or Grade 6 and therefore have to administer the provincial standardised test on mathematics and language. In the following paragraphs I highlight some of the educators critical insight into how emphasis on literacy and numeracy development may impact their scientific pedagogical practices, which has implications for minority students scientific literacy development experiences.

Annie discusses why she does not have the “initiative” or “drive” to focus on the science curriculum:

I think for Grade 6, this is horrible but the emphasis is on math and literacy and for me to improve my scores. It’s the areas that are the most important or evident when you are looking at a students work and science is one of the areas that are secondary. After doing three years of doing EQAO it shouldn’t be secondary it should be on an equal playing field with mathematics and literacy. There needs to be some hand holding in terms of teaching science like they have done with math and literacy. They have really said this is how you teach it and this is what good teaching is. I can go to the Ministry resources and get videos on how to be an effective math and literacy teacher. If we want the same focus on science you need to give us the tools to be able to do that and give us the time to do that too.

Moreover, she discusses how the lack of time affects her ability to program meaningful activities for her students. She contends:

It’s easy to integrate Language throughout your day, right? There is not a lot of time for science, meaning that we don’t give enough time for them to explore. I plan for two periods a week and within those two periods you have to get these concepts in, right? I think it hit me when I had a student-teacher. She was so focused on delivering the content and getting them to understand it but there was no exploration time. It’s almost like okay we have to do our math, it’s non-negotiable to have math, it’s non-negotiable to have literacy because you have to have those literacy blocks but science… we teach it but not to the fullest level that we can be, that’s what I think… I think we need to go beyond, I think if we are going to be really effective science teachers then we need to go beyond just getting a resource and taking it and doing it. That’s what the Bill Nye and Hands-on Science program is because they give it to you and you just read off of it. However, if we can invent practices that can connect to our different students then that’s more meaningful but that’s hard and that’s where the time comes in. Not just time in delivering it but planning it. It’s like non-negotiable to plan for math
and literacy but for science it’s too hard so you put programming off for next year.

According to Annie there is this general assumption that mathematics and literacy development takes precedent over scientific literacy, where the overall perception of science as a secondary subject needs to change. Moreover, despite the lack of time for science programming, Annie highlights the need for science educators to critically engage in developing effective science programs that allow students to make meaningful connections to science learning.

Ben provides reasons for why he considers science a ‘secondary discourse’ compared to other school subjects:

There is a hierarchy of literacy awareness or literacy concerns and at the top of that hierarchy is language or language literacy. In a matter of fact, usually when you say literacy it is synonymous with language. When you hear say something like science literacy I do a double take because is that literacy? In the broadest sense of the word, literacy being the level of knowledge, skill, or expertise that you have in the subject area. I may be wrong, but that there is a prevailing sense that the subject of scientific literacy is something that is secondary. There is a strong emphasis on language where you have ESL programs and a variety of support structures in place to help students to develop language literacy. We want them to be fluent in the reading, writing, and communication components of language literacy. A very close second to that is the emphasis and focus on math literacy. So much so, that you have programs like EQAO to assess both the language and math literacy levels of students in Grade 3, 6, 9, and 10.

In addition, he discusses the challenges he experiences when programming for science in his class:

In terms of challenges in science, one of the things that come to mind right away is limited time. The very nature of science exploration, discovery, research and need for observation… a common thread through all of this is the need for putting in the time to accomplish the goals. It is interesting to see teachers plan and with that in mind it is not uncommon to see strategies doubling up on science periods so that you have enough time. Time to pull your resources together and get your scientific equipment in place. Time for that preparation and delivery of the lesson and time for putting things back in place and cleaning up. So, I would identify limited time on a daily basis to teach your science lesson during the science period. In a more general sense, in a school year you have so much time to deliver a curriculum… Availability of resources is also a challenge at my school. Every year the Grade team meets where there seems to be a constant need to get materials and resources in order to replenish supplies and ensure that students
have what they need to fully understand and experience the curriculum and to fully understand the content of the curriculum. So, limited resources in terms of the resources themselves, the scientific tools, equipment that they need, and the funds to produce these resources. So, these are just couple of the challenges associated with developing a science program.

Ben calls attention to the differences in the school literacies and how math and numeracy are more highly valued because of provincial testing (i.e., EQAO). Moreover, Ben identifies time constraints and resources as challenges that affect his science programming and therefore the experiences of his students.

Similarly, Helen places an emphasis on the Grade Six EQAO, where she uses a cross-curricular approach to science learning in her class. She contends the following:

Another challenge is how science is low on the totem pole in terms of importance. Grade 6 EQAO takes top-notch priority and so Language and Math skills are probably paramount to anything else because that’s what EQAO tests. I know that we integrate a lot of our science into our reading but it’s still not as important as in Grade 6 as other subjects because of the test that comes at the end of the year.

Based on Helen’s statements it would seem as if the learning that takes place in her class centers on developing her students’ skills to be successful in the Grade 6 EQAO test.

Both Denise and John discuss how emphasis placed on provincialized tests in school cultures limits science educators’ ability to effectively address diverse students scientific literacy development. Denise states the following:

Teaching science is one of those subjects that fall on the wayside. You don’t get the same type of support you do with literacy and numeracy and you don’t get the same types of workshops. You’re not asked to be held accountable in any way. For all that we complain about EQAO and what not, and for better or worse, teachers are held to a sense of accountability when it comes to testing. There are people who feel it’s a reflection of their teaching practices and they have to be held accountable to their kids. For science I am not saying that I agree with province testing but with the accountability teachers are provided with workshop, extra training, PD, extra personnel, finance, and personnel, and lots of other support. So, science and social studies does not get that support. It’s something you have to sign on to do workshop at your on will and if the teacher doesn’t want to do it they don’t have too. So if you want a good science program and if you want students to walk students to walk away with solid science knowledge then you have to provide teachers with the exact same supports as literacy and math.
John states:

I know that one of the reasons why I wouldn’t focus on the sociocultural parts of the science education is because of a lot of the schools and the Board in general doesn’t really focus on giving teachers the resources or the professional development in order how to train the teachers on how to do it. Through my five years of teaching I can’t remember off the top of my head any professional development focused around science curriculum. I don’t remember there being a lot of resources for the science curriculum, unless this is something that is discussed at the grade level and the grade level decide to get some resources, which again even the Grade Level they focus on Language and Math and that’s what administrators focuses on and that’s what the Peel Board focuses on because in the end that’s what EQAO is on…and they don’t care about…well, maybe not that they don’t care but that they care more about showing how are students are progressing in the subjects, such as language and mathematics. The subjects that the public cares about and not about subjects like science.

The aforementioned educators highlight the need for all elementary educators to be held accountable for developing effective science programs. It is their assumption that if educators receive school support (i.e., workshops, professional development) within the school environment then these issues would become more an integral part of educational discourses and pedagogical practices.

Overall, the educators’ response highlights the need for challenging dominant notions that science is a ‘secondary’ subject, as it may have implications for students’ science educational outcomes. Research shows that minority students experience ‘scientific educational disadvantages’ (Bouillion & Gomez, 2001; Calabrese-Barton, Ermer, Burkett, & Osborne, 2003; Emdin, 2012; Varelas, Kane, Tucker-Raymond & Pappas, 2011) which ultimately affects their scientific educational trajectories. However, if educators and administrators (e.g., principals and superintendents) are predominately concerned with improving the academic performance of their students in certain subject areas (i.e. math and language) it may affect teachers’ priorities in developing effective science programs, which systematically address diverse students’ scientific literacy.
Diamond & Spillane (2004) conducted research in four urban elementary schools to examine how these schools respond to high-stakes accountability policies. Their research findings show that in elementary education, mathematics, science, and language arts instruction are differentially valued. Specifically, they found a general pattern when compared to mathematics and language arts instruction; science had (1) fewer formal and informal subject matter leaders, (2) less attention from school administrators, and (3) fewer instructional specialists. In addition, standardized accountability policies contributed to the undervaluing of science education in both high and low performing schools. Overall, the scholars found that science education in urban school communities received less attention than language arts and math. As a result, this may suggest that due to emphasis placed on literacy and numeracy development, educators are not utilizing effectively pedagogical practices to build minority and or diverse students scientific literacy.

In recent years, science educational discourse has focused on the use of science inquiry activities to engage students of diverse sociocultural backgrounds (Fradd & Lee, 1999; Cuevas, et al., 2005; Lee, 2002b; Lee et al., 2006; Rosebery, Warren, & Conant, 1992; Warren, et al., 2001). All of the educators in my study identified lack of time as a key factor affecting their science instruction. As a result, these educators rely heavily on scientific inquiry-based practices (i.e., hands-on science activities, experiments) as means to develop diverse students scientific literacy. The Ontario Ministry of Education (2007) is a major proponent for elementary educators using science inquiry learning activities (i.e. experimentation and research skills) in the science classroom. Specifically, the Ministry claims that scientific inquiry-based activities allows for the development of science skills that are relevant to students’ lived experiences/realities.
Despite the fact that the elementary educators work in school spaces where there is limited resources for science instruction (i.e., equipment and textbooks) all of the educators advocated for the use of scientific inquiry to develop diverse students scientific literacy.

In my study, Ben was the only educator who explicitly recognized the importance of connecting science inquiry practices to students’ sociocultural background. He claims the following:

For example, I teach a science unit on flight and I like to tap into my students’ personal experience… It gives me great pleasure not to just explore the curriculum but to go beyond it where I really look into something like a kite. I think the concept of a kite has a cultural component, which varies between cultures, such as Canadian, West Indian, and South Asian cultures. Part of my responsibility as a professional is to do that personal research and to find out information. I have to do that on my part and I think I need to and I have to invite a sharing of knowledge. Here is what I know what do you know? It will give any teacher great pleasure to hear from the student and it gives the child an opportunity to share his or her knowledge that may be specific and unique depending on where he or she is coming from. So, call attention to what might be different in terms of what the child has to offer. I use the flight example where the students get the opportunity to make a model of something that flies. A child who is coming from a different background outside of Canada brings in a special kind of kite. So, you call attention to it because this is new to us and it’s a learning experience for us living in a Canadian context. We are familiar with kites but lets see what is similar and what is different. This creates a real good learning opportunity by the differences that you can see…[Give] the child an opportunity to experience not just the learning experience or acquiring of knowledge but beyond that a sense of pride of association and connection with something that is unique or maybe different.

Ben actively encourages his students to share their own sociocultural perspectives on scientific concepts learned in class. Moreover, he provides opportunities for students to use their own cultural backgrounds in science inquiry activities, as means to access the scientific knowledge. He recognizes the importance of students making meaningful or personalised connections to the school science learning.

Similarly, Annie describes how science inquiry activities have been a success in her science program:
I like to connect science learning to hands on experience. So I might connect the learning to a field trip but I also follow it up with other science activities too. So going to like the Kortright Centre and Conservation and doing anything that involves extracurricular activities where they go out and get the experts to teach the kids because I might not be that strong in that area but having the experts come is important. When I taught Grade two I had a student whose parents where from Mexico doing work-study here in Canada. The parent was a Molecular Biologist and so he came in and he wanted to teach the kids about plants. So he did a slideshow presentation about plants, even though the kids were like ‘what?’ but it was good it was a different way of learning. I think the more I look at in teaching kids so many of the products that we use or even the resources we use are so dumb-downed making it look cutesy but sometimes it’s just nice to get them to just think. To really struggle with those ideas and concepts even using those big words, they don’t understand it but they have to figure out what it means. I guess that is one of the successes is connecting science concepts to some hands on relatable experience.

Annie centers her science program around hands-on science activities and community partnerships in order to engage the diverse learners in her class. It is important to Annie to provide her students with meaningful activities that her students can relate to on some level.

In addition, Helen advocates for the use of science inquiry because her students enjoy the activities, and furthermore, everyone can participate in the science learning experiences. She states the following about her students:

They love hands-on science activities, for instance with flight we built model airplanes they were totally engaged in that. Some of them had to make their planes flip or roll and some had to have their plane go the furthest distance so you’re looking at aerodynamics. I think having hands on activities for the students and trying to get them interested in the topics through those activities has been a very big success.

According to Helen’s statement, she feels that her science program has been successful because all her students, regardless of sociocultural background, are able to understand scientific concepts through experiential learning activities.

Wyatt teaches in a socio-culturally diverse classroom and bases his entire science program on the hands-on science approach/model. He states the following:

The bulk of my science program is done through the hands-on science program. So, if you are fortunate enough to get a kit it comes with all the stuff you need to
do the program. Also, most of the schools have hands-on textbooks but they don’t have the resources that go with it. So that’s half the program I mean it’s great to know what you have to teach and what you are expected to find... So, if you can get your hands on a science kit that thing is a lifesaver. So I am going to say that 90% of my science program is straight up hands-on science.

As claimed by Wyatt, the hands-on science program provides him with the necessary tools to effectively teach science to his students. However, he does not necessarily consider how the hands-on science approach directly addresses the individual needs of his diverse learners.

In the 2007 Ontario Science and Technology curriculum document it outlines the Ministry’s expectations on science inquiry learning:

Research and successful classroom practice have shown that an inquiry approach, with emphasis on learning through concrete, hands-on experiences, best enables students to develop the conceptual foundation they need. When planning science and technology programs, teachers will provide activities and challenges that actively engage students in inquiries that honour the ideas and skills students bring to them, while further deepening their conceptual understanding and essential skills. (p.30)

Moreover, the Ministry states the overall objective of science inquiry activities as:

The activities offered should enable students to relate and apply these concepts to the social, environmental, and economic conditions and concerns of the world in which they live. Opportunities to relate knowledge and skills to these wider contexts will motivate students to learn in a meaningful way and to become lifelong learners. (p.9)

It is the Ministry’s opinion that science inquiry should extend beyond simple experiments but afford students the opportunity to use their own ideas and skills (i.e., lived experiences) to access school scientific knowledge. Lee (2002a) examines scientific inquiry with elementary students from diverse cultures and languages. Specifically she identifies three major dimensions of promoting scientific inquiry with socio-culturally diverse students: (1) discourse processes in classroom communication and interaction, which refers to the need for science educators to actively integrate diverse students various patterns of discourse into science pedagogical practices, and (2) cultural values and practices related to scientific inquiry and, (3) children's
cognition, based on their cultural knowledge of scientific inquiry, acknowledges the notion of incompatibility and compatibility between diverse students’ science experiences and the nature of Western Modern Sciences and scientific inquiry. Lee contends that diverse groups have understandings of science that may be incompatible with traditional Western modern science understandings of the nature of science and scientific inquiry.

Consequently, if educators adopt scientific inquiry practices that are reflective of the norms and practices of Western modern science it can create barriers for diverse students’ science academic performance (p.34). As a result, Lee (2002) states that it is important for educators to allow students to “make smooth transitions between their home culture and the culture of science” (p.40). Even though the educators in the study use ‘hands on’ science approaches to develop diverse students’ scientific literacy, it does not necessarily mean that the individual needs of the diverse learners are being met through these activities. Keys & Bryan (2001) state that there is a limited amount of research on teacher knowledge used in inquiry-based instruction. Lee & Fradd (1998) contend that, “teachers who are knowledgeable about science but not about the cultures of their students may emphasize inquiry without making science relevant to students” (p.16). Hence, there is a need for science educators to be socio-culturally conscious of students’ diverse backgrounds, in order to make scientific learning relevant and meaningful to students’ lived experiences.

In my study the educators prescribed to the science inquiry approach because it was considered an effective approach to teaching scientific concepts. None of the educators, except for Ben implemented science inquiry as a means to account for students’ sociocultural diversity. As already mentioned, in the Ontario science curriculum, the Ministry advocates for science inquiry approach. However, the Ministry does not provide any concrete discussion on scientific inquiry and student diversity issues, specifically on strategies or resources that educators can use
in order to effectively implement science inquiry practices that include students’ sociocultural background.

**6.2 Training and Support for Elementary Science Educators**

All of the elementary educators stated that they required more knowledge, support, resources, workshops, and training on how to teach science to diverse students. Specifically, educators feel it is the responsibility of the school board or school personnel (i.e., administrators) to provide them with professional development opportunities in the areas of equity, inclusion, and or diversity. In the following paragraphs I highlight some of the participants who have similar understandings about the support needed for elementary educators to effectively address student diversity issues in their science educational processes.

Annie, William, Helen, and John all discussed professional development and teacher collaboration as important in providing elementary educators support in developing diverse students’ scientific literacy.

Annie states,

So I guess continued training and Ministry resources would be good, well, workshops for us because we need to have that incentive to know the content knowledge and really understand it. If I don’t understand the science curriculum then I am in trouble. I have to admit the first few years of teaching I didn’t know the curriculum as much as I did know now. You have to know the curriculum and I think it goes back to the standards of professional practice, like your commitment to student learning, commitment to processional learning, commitment to community involvement all those areas you need to focus and you can’t forget it or just switch it off. As a teacher, you are in the classroom and you have so much leeway in how you want to deliver your program no one is policing you unless your principal likes to stand in your doorway. So how do we become accountable for what we do? I think adhering to the standards of practice really helps, so one of the big areas is engaging in professional development is really important but I think some teachers acquire bad habits because they don’t know anything else. If we take the initiative to learn then I think it’s better and also time too, giving us time to do it.
Similarly, William discusses the importance of teacher accountability through professional development opportunities. He states:

[We] should have workshops and professional development days where you take workshops on equity and diversity. A lot of teachers probably don’t even know what those words mean so that is something that should be implemented and should be an initiative… Also, definitely having professional days on equity and diversity helps. In teachers college I was streamed into the Regent Park program and a big focus on that was equity and diversity. Growing up in the area that I grew up in, I got it and I understood it. Also, I learned in high school that a lot of teachers weren’t open to teaching students of my descent or my background in terms of behavior…You have teachers within my school who are trying to implement equity and diversity and showing kids that as much as we are alike and we are also different and those differences need to be highlighted in their work. How you teach, and how you respond to students. Again, we need workshops and staff meetings even dedicated to gender issues in the classroom, race… I don’t know… you know just having more equity and diversity implemented in your staff meetings and having professional development days.

Helen provides a critical view on how elementary educators can receive support to develop effective science programs, she states:

To support elementary educators in teaching diverse students, well I think there is a lot that we can use. It’s probably not going to happen but I think there is a lot that we can use. I think that our resources are limited, as far as terms of budgets go. So I think the money will be spent in areas where there is probably more of a need, as far as image goes, in terms of EQAO scores in relation to others in the Board or province… I think having resources is one of the biggest things especially when teaching diverse students you need a range of literature to help them and if you don’t have something at their level it’s hard for them to understand. So having a range of resources would be really helpful. Also time I feel like I don’t’ have enough time for teachers to collaborate and certainly not for diversity. We collaborate on stuff but it’s usually EQAO and Teaching Learning Critical Pathways (TLCP) stuff. I find that time is not something we have a lot of and teaching diverse kids is not something that is of high priority on our lists because getting our scores up is our first priority. I find that talking with teachers, particularly this year, everyone in my school is running ragged all day everyday and they don’t even have time to stop for five minutes let alone teaching diverse students science. So I think if we had time to collaborate with other teachers and talk about their different experiences. I think when you talk to other teachers you get really good ideas and I think that is one of the best source of ideas. We really don’t have the opportunity these days with the new report cards and a lot of the extra things that are placed on us… I think also some PD (professional development) on different things we spend all of our PD on getting our scores up in math and language. We don’t spend our PD on anything else that’s basically what we spend all of our PD on. So you know having some PD on how to teach
diverse students in science would be great and how to help students with different needs and backgrounds. We don’t have PD on those sorts of things and it would be valuable but I know that it probably won’t happen unless they start doing a science EQAO.

Helen is not necessarily convinced that elementary educators will receive support in the area of student diversity and science education because of resources (i.e., funding) spent on EQAO. However, she does feel that time allotted to collaborate with colleagues would be an effective tool or strategy to allow educators to exchange ideas on how to deal with the issues that they experience in the classroom.

Also, John states the following,

I think it’s important for supporting elementary teachers that we first need to have a lot of professional development in the area of science. I think that again math and language is focused on a lot and science, social studies, and physical education are pushed to the back burner and there are no funding for these until there is a public outcry and there starts to be a lot of more people shouting out for it. It takes more than teachers saying we need it takes the public to realize it’s needed for them to start writing letters to the government. The scientific literacy of student is definitely for crucial for students to know if we were to focus on these other subjects it helps with the math and language and it’s not taking away from these other subjects and having good teachers who know how to teach these subjects. A lot of teachers could use support in making sure that at the Grade 6 level there is a lot of opportunities to work together and blend different subjects, such as working literacy in the science program. There is a lot of good science articles that are out there where you can work with comprehension skills, so teachers can use a lot of help in planning out a blended curriculum where can be assessing different strands or subjects all at once.

John acknowledges that scientific literacy of students is important, however, it is the school culture that does not necessarily allow for time and the support needed to construct effective science programs within schools.

Overall, the aforementioned educators identify the need for professional development (i.e., training or workshops) and teacher collaboration, in the areas of equity and inclusion, which they feel will impact elementary educators’ pedagogical practices and understandings of minority students. The educators’ views are reflective of educational scholars who cite ‘teacher
quality’ issues in science education as a key factor in the diverse students scientific academic success (Champagne & Hornig, 2006). Specifically, researchers claim that teachers are underprepared in addressing both science content and students sociocultural backgrounds (Buxton, Lee & Santau, 2008; Bryan & Atwater, 2002; Rodriguez & Kitchen, 2005; Van Garderen, Hanuscin, Lee & Kohn, 2012). Knight & Wiseman (2009) claim that educator’s lack of awareness about sociocultural pedagogical practices for classrooms may be due to a lack of knowledge on education and diverse students. Consequently, professional development is needed for educators to acquire intercultural skills and knowledge to effectively understand the nature of diverse classrooms.

The Ontario Equity and Inclusion Education Strategy (2009a) states that the Ministry and school boards will work together, collectively to provide local schools with support of developing and implementing equity and inclusion based policies. In terms of support for educators, the Ministry states that it will “work with education and equity organizations to create innovative partnerships for supporting and implementing the strategy through training, resources, and other activities” (p. 18). Moreover, the Ministry states that in the fourth year of the strategy, local school boards should “provide opportunities for students, administrators, teachers, support staff, and trustees to participate in equity and inclusive education training and leadership initiatives” (p.23). The Ministry’s statements suggest that there are support systems in place for educators to receive training in the area of equity and inclusion. In addition, it is the Ministry’s expectation that school boards will provide the same opportunities for their staff personnel in local schools. For example, two of the largest school boards located in the GTA have equity policies where in both of these document the boards discuss a commitment to providing “staff development” (i.e., training) in the areas of equity and inclusion.

However, in my study the educators, who work in these GTA school boards, claim that
there is a lack of opportunities to engage in equity and inclusion related professional development. Consequently, this may suggest two things: (1) educators are not actively seeking out professional development opportunities provided by Boards, which may suggest a lack of interest in doing so, or (2) school boards are not actively encouraging staff personnel (i.e., principals, educators) in schools to engage in professional development activities in equity and inclusion education. In my research study, the educators proposed teacher collaboration as important for supporting elementary educators’ development of diverse students’ scientific literacy. Van Garderen, Hanuscin, Lee, and Kohn (2012) contend that teaching science to diverse learners can be a challenge because teachers may be underprepared and lack the knowledge to address the diverse students in the classroom. Consequently, they propose a collaborative approach between science educators and special educators as an effective way to increase responsiveness to the need of their diverse learners in the classroom. However, teacher collaboration in science should be also a part of professional development programs.

Scholars have found that professional development in the area of collaboration resulted in improvements in science educators’ knowledge and pedagogical practices to meet the needs of diverse learners. In the past few decades, science education research has advocated the use of teacher collaboration as a strategy to improve in-service and pre-service elementary science teaching (Suntisukwongchote, 2004; Van Garderen, Hanuscin, Lee, & Kohn, 2012). According to Barufaldi & Reinhartz (2001) “collaboration is the cornerstone of developing and implementing successful science professional development” (p.93). The scholars propose “active collaboration” as successful strategy that can be used for developing and implementing successful science professional development.

Elementary science educators should be working collectively rather than individually to improve science teaching. Barufaldi & Reinhartz (2001) identify four major components of
teacher collaboration: (1) shared vision, which refers to stakeholders, and or, the collaborator’s working together to develop clear goals and objectives; (2) interconnectivity, which relates to the idea that amongst and between the individuals there is a sense of ownership and commitment to the shared vision; (3) a multi-tiered process of involvement and support in the collaborative process; (4) shared resources and rewards, where teachers support each other in improving their science instruction and share materials, and or activities. The literature shows that collaboration is an effective strategy for supporting elementary teachers working with diverse students.

Lee & Fradd (2001) conducted a study where elementary science educators engaged in teacher collaboration as a means to learn how to effectively develop the scientific literacy of culturally and linguistically diverse students. Specifically, the educators attend workshops where they engaged in science activities, discussed key science concepts and big ideas, and shared teaching strategies. The findings showed that through teacher collaboration the science educators were able to understand how to promote culturally linguistically diverse students’ achievement in science. Consequently, if educators are provided with opportunities to engage in professional development activities, such as teacher collaboration, it affects the quality of educators’ science teaching instruction because the development addresses the critical issues that are relevant and important to the educators. However, the whole entire educational system must be held accountable for ensuring that elementary science educators receive the support needed to effectively develop diverse students’ scientific academic achievement in school spaces.
Chapter Seven: Conclusion

The sociocultural heterogeneity of students in Ontario schools has challenged the nature of Western school science education. In response, academic scholars have focused on the scientific literacy development of diverse students and how elementary science practitioners can effectively respond to students’ sociocultural differences in science school spaces.

7.1 Emerging Themes

In Chapter Five, I explored elementary educators knowledge and or understanding of student diversity issues in science education. All of the elementary educators have experience teaching in schools that have large populations of students of varying sociocultural backgrounds. Furthermore, all of the elementary educators teach science to diverse students. The elementary educators had similar understandings of the interrelationship between students’ sociocultural background and science literacy development. Specifically, the educators identified multiple sociocultural variables (e.g., social class, culture, language, gender) as affecting students’ scientific literacy development or academic success in science. Moreover, the educators consciously or unconsciously connected student diversity to scientific pedagogical practices creating spaces in the science classroom for students to access the science curriculum, in spite of barriers, such as limited resources and culturally relevant materials. However, my study highlighted the need for educators to extend their notions of student diversity and science education to include alternative forms of science educational models that address the sociocultural context of science education. Moreover, none of the elementary educators discussed the intersectionality of sociocultural variables in reproducing systemic inequities in the
Evidently, the educators only focused more specifically on specific variables that they perceived to be relevant or an issue in their science classroom spaces.

In terms of official discourses on student diversity in science education, only one elementary educator was aware of the revisions to the Ontario Ministry of Education Science and Technology curriculum (2007), which includes a section on science and technology education program planning considerations. Within this section, is presented the program planning consideration on antidiscrimination science and technology education, which outlines information and strategies on how educators can account for students’ sociocultural diversity in science classroom spaces. The other seven remaining elementary educators had provided their own understandings of program planning considerations, which reflected the Ministry’s ideas as outlined in the science curriculum document. Nonetheless, the elementary educators’ unawareness calls attention to the need for curriculum support in school subject areas, in particular, science.

In Chapter Six, I analyzed the obstacles experienced by elementary educators in teaching elementary school science. All of the educators claimed that provincial standardized testing, such as EQAO, limits their scientific pedagogical practices and time and resources for science. The educators discussed how their school environments places emphasis on increasing students’ mathematics and language skills development rather than students’ scientific literacy development. All of the educators use science-inquiry activities, hands on science and, or experiential learning activities. According to the educators they use hands-on activities because they feel it’s an effective way to develop students’ scientific literacy regardless of sociocultural background. Ben is the only educator that discussed how he uses students’ sociocultural background to access scientific concepts in science inquiry activities.
All the participants identify the need to increase professional development opportunities, such as training and workshops, in the area of student diversity and science education, as an important factor in supporting elementary educators. William contends that it would improve educators’ scientific pedagogical practices and Annie feels that it would provide a sense of accountability in science education. The educators suggest teacher collaboration as an effective strategy of professional development because it allows educators opportunities to share pedagogical practices and learn from experienced and specialized teachers, who may provide insight into developing the scientific literacy of socio-culturally diverse students.

Overall the use of the qualitative approach in the research study was effective in highlighting some key issues and new insights into sociocultural perspectives in elementary school science education. Although the eight semi-structured interviews provided me with some understanding of elementary educators’ perspectives on teaching science to diverse student populations of varying sociocultural backgrounds, it is not necessarily representative of all the science elementary educators in Ontario schools. Consequently, generalizations about elementary science educators’ understandings of science education and student diversity should not be made beyond this research study. Rather, the elementary educators’ perspectives provide new data about issues in developing socio-culturally diverse students’ scientific literacy and overall effectiveness of school science educational reform initiatives in the area of student diversity.

7.2 Key Issues

The first issue presented in the study is the need for elementary educators to acquire clear understandings of the interrelationship between students’ sociocultural backgrounds and
scientific literacy development (Carter 2008; Lemke, 2001). According to Lee (2005b),
literature on the intersection between diversity and equity in science education is a relatively new
area of study. As such, there is a limited amount of concrete knowledge and resources on how
elementary science educators can effectively respond to student diversity issues in science
classroom spaces. Over the past couple of decades, the science educational community and
Western school science educational reform efforts have stressed the need for educators to be able
to address the diverse needs of students, but more needs to be done (AAAS, 1990, Ontario
Ministry of Education, Revised, 2007). Differences in elementary educators understanding and
overall consciousness of student diversity issues serve as challenges for achieving science
educational equity for diverse students in school spaces. As a result, their understandings shape
their scientific pedagogical practices, which in turn impacts students’ school scientific literacy
experiences.

A second issue evident in the study is the need for addressing teacher accountability
issues in science education. Findings reveal that the eight elementary educators characterize
science as ‘secondary literacy’ in comparison to mathematics and language, which has
implications for the quality in science programming, as it relates to diverse students’ scientific
literacy development. The elementary educators placed emphasis on developing students’
numeracy and literacy skills due to the pressure of improving student success in provincial
standardized testing. This may suggest that science is not necessarily of importance in school
programming, because of high-stake accountability tests, such as EQAO. Overall, the educators
are not actively addressing the diverse needs of students in the science classroom, which has
significant implications for minority students who do not have the sociocultural capital to
participate in mainstream school science. As a result, my study highlights the need for
accountability in science education, in particular, research on science teacher quality issues in the area of student diversity, equity, and inclusion.

A third issue is the need for professional learning support for elementary educators in teaching science to diverse students. The elementary educators sensed a lack of support by school boards/schools in learning how to effectively teach diverse students. Even though official discourses (i.e., Ontario Ministry of Education document and school board policies) indicate that professional learning opportunities are available, lack of support by school personnel remain a challenge for elementary educators that are actively seeking training and or workshops in the area of student diversity. Science educational research shows that professional development is necessary to improve science educators (i.e., pre-service and in-service teachers) pedagogical practices (Hudson, 2005; Levitt, 2002; Shapiro, 2006). Hence there is a need for more research studies on the professional development of in-service elementary science educators in sociocultural diverse classrooms.

7.3 Conceptual Framework: Considerations and Reflections

My research study was guided by the lenses of critical pedagogy and antiracism, where the elementary educators critically reflected and interrogated their own perspectives on teaching science to socio-culturally diverse students in mainstream school science spaces.

My findings show that critical pedagogy, a praxis where action and theory forge a relationship, is necessary for educators to actively bring about social change or transformation in science educational systems (Monchinski, 2008). All of the elementary educators in the study were conscious of student diversity issues (i.e., race, culture, gender, class) and acknowledged that these issues have an impact on diverse students’ scientific literacy development. By
exploring the complex interrelationship between diverse students sociocultural background and science education it allowed the educators to gain an understanding of their role in constructing and implementing equitable and inclusive based science educational classroom models. Moreover, the elementary educators were able to provide critical insight into the challenges of science educational systems such as lack of time, resources and support, and provincial standardized testing, which could be addressed in future research studies on student diversity issues and science education.

In the context of antiracism, elementary educators were able to consider how social inequities are reproduced in science educational settings, which specifically affect the scientific literacy development of diverse students. The majority of the elementary educators had limited knowledge of official discourses on equity and inclusion and implications for mainstream science educational practices. As a result, if elementary educators lack a clear understanding of how school science spaces reproduce oppressive and inequitable power relations amongst students then school science educational models cannot be actively transformed.

Overall, my qualitative research study reveals how critical pedagogy and antiracism can be used to deconstruct and examine student diversity issues in Western science educational models. Despite recent science educational reform efforts in Ontario to address issues of equity, inclusion, and diversity, there is a considerable amount of work that needs to be done to reform the state of science education in Ontario schools. As a result, I hope my research study will highlight student diversity issues that exist in school science and possibly lead to discussions amongst all educational stakeholders on how to positively transform school scientific practices and processes to equitably address the needs of socio-culturally diverse students.
References


McRobbie (Eds.), *Second international handbook of science education*, (pp. 59-68). New York: Springer.


(Ed.) Educators’ Discourse on Student Diversity in Canada: Context, Policy, and Practice (pp.81-108). Toronto: Canadian Scholars Press.


Labuschagne, A. (2003). Qualitative research: Airy fairy or fundamental? The Qualitative Report, 8(1), 6-10.


Ogunniyi, M.B. (2007a). Teachers’ stances and practical arguments regarding a science
indigenous knowledge curriculum: Part I. *International Journal of Science Education*,
29(8), 963-986.

Ogunniyi, M.B. (2007b). Teachers’ stances and practical arguments regarding a science
indigenous knowledge curriculum: Part II. *International Journal of Science Education*,
29(10), 1189-1207.

Ontario Ministry of Education. (1998). *The Ontario Curriculum, Grades 1-8: Science and
Technology, 1997*. Queen’s Printer. Retrieved February 21, 2012, from
http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec18curr.pdf

Ontario Ministry of Education. (2007). *The Ontario Curriculum, Grades 1-8: Science and
Technology, 2007*. Queen’s Printer. Retrieved February 21, 2012, from
http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec18currb.pdf

Ontario Ministry of Education. (2009a). *Ontario’s Equity and Inclusive Education Strategy:
Realizing the Promise of Diversity*. Queen’s Printer. Retrieved March 15, 2012, from

Ontario Ministry of Education. (2009b). *Policy/Program Memorandum No.119: Developing
and implementing equity and inclusive education policies in Ontario schools*”. Queen’s
Printer. Retrieved March 15, 2012, from

Ontario Ministry of Education. (2009c). *Equity and inclusive education in Ontario schools:
Guidelines for policy development and implementation*. Queen’s Printer. Retrieved

in Ontario's schools, First edition covering Grades 1 to 12. Queen’s Printer. Retrieved


Posnanski, T. J. (2002). Professional development programs for elementary science teachers: An
analysis of teacher self-efficacy beliefs and a professional development model. *Journal of
Science Teacher Education, 13*(2), 189 – 220.

Rakow, S.J., & Bermudez, A.B. (1993). Science as 'ciencia': Meeting the needs of Hispanic


Appendix 1

Participant Consent Form

June 2012,

To the participants in this study,

I am a Masters of Arts student at OISE/UofT in the Curriculum Studies and Teacher Development program. I am currently working on my MA degree thesis entitled, “Elementary Teachers’ Perspectives on Teaching Science to Socio-culturally Diverse Students”. This research study aims to contribute to educational discourse on diversity issues in science education. Specifically, I hope to gain critical insight into elementary science teachers’ perspectives on teaching science to socio-culturally diverse students, in the context of official discourse (e.g., Ontario Ministry documents) on equity and inclusion and student diversity in science education. Also, the study aims to highlight some of the successes and challenges that elementary teachers’ experience working with diverse/minority students and the possibility of transforming elementary teachers’ pedagogical practices in the area of student diversity and science education issues.

This research study will be carried out in the Greater Toronto Area and under the supervision of Professor Diane Gérin-Lajoie, Department of Curriculum, Teaching and Learning, The Ontario Institute for Studies in Education/University of Toronto. The project will be carried out between the months of June 2012 to January 2013. Participants of the research study will consist of eight elementary teachers who have experience teaching science in a diverse school population. Participants will be chosen based on the number of years of teaching experience (i.e., greater than four), identity (i.e., race/ethnicity, age, and gender), and experience working with diverse/minority students.

Participating in the study will involve participants taking place in a face-to-face interview between 60-90 minutes in length. During the interview you will be asked questions about: (1) your perspectives/views on school science education and teaching science to diverse students; (2) your experiences in developing the scientific literacy of diverse students; (3) the way you perceive/understand equity and inclusion and diversity issues in science education in the context of Board policies; (4) and science program planning as outlined in the Elementary Ontario Ministry of Education Science and Technology (2007) curriculum document.

As the interview proceeds, I may ask questions for clarification or further understanding, but my part will be mainly to listen to you speak about your views, experiences, and the reasons you believe the things you do. During and after the interview, I will write brief notes that will be used to assist me in remembering the surroundings of the interview (i.e., characteristics of the site).

It is the intention that each interview will be audio taped and later transcribed to paper; you have the choice of declining to have the interview taped. You will be assigned a number that will correspond to your interviews and transcriptions. You can request to review and make changes to your transcript in order to add any further information or to correct any misinterpretations that
could result. The information obtained in the interview will be kept in strict confidence and stored at a secure location. All information will be reported in such a way that individual persons cannot be identified. All raw data (i.e. transcripts, field notes) will be destroyed five years after the completion of the study.

You may at any time refuse to answer a question or withdraw from the interview process. You may request that any information, whether in written form or audiotape, be eliminated from the project. At no time will value judgments be placed on your responses nor will any evaluation be made of your effectiveness as a principal.

Finally, you are free to ask any questions about the research and your involvement with it and may request a summary of the findings of the study.

If you have any questions, please feel free to contact me at (416) 875-1200 or at jr.gayle@utoronto.ca

You may also contact my supervisor, Professor Diane Gérin-Lajoie at (416) 978-1993 Finally, you may also contact the U of T Office of Research Ethics for questions about your rights as a research participant at ethics.review@utoronto.ca or 416-946-3273.

Thank you in advance for your participation.

Janice Gayle  
MA student, CTL  
OISE/University of Toronto  
Telephone: 416-875-1200  
Email: jr.gayle@utoronto.ca

Dr. Diane Gérin-Lajoie  
Professor, CTL  
OISE/University of Toronto  
Telephone: 416) 978-1993  
Email: diane.gerin.lajoie@utoronto.ca

By signing below, you are indicating that you are willing to participate in the study, you have received a copy of this letter, and you are fully aware of the conditions above.

Name: __________________________________________

Signed: ___________________________ Date: ___________________________

Please initial if you would like a summary of the findings of the study upon completion: ______

Please keep a copy of this form for your records.
Appendix 2

Interview Questions

PROFESSIONAL BACKGROUND IN SCIENCE EDUCATION

1. Tell me about why you became an elementary teacher?
2. Describe to me your teaching career and current teaching position?
3. Tell me about the types of learners you have in your current classroom?
4. What is your personal understanding/belief of school scientific literacy?

SCIENTIFIC LITERACY DEVELOPMENT OF MINORITY STUDENTS

5. In your experience, what has been some of the successes or challenges you have experienced in developing a science program?
6. What is your understanding (i.e. opinion) of student diversity issues in science education?
7. How do you include students' sociocultural (e.g., race/gender, social class, etc.,) background into science education processes (e.g., teaching/learning)?

OFFICIAL DISCOURSES ON STUDENT DIVERSITY AND SCIENCE EDUCATION

8. What is your understanding of Board policies on equity and or inclusion?
9. At your current school, what are some Board policies or school initiatives that your school has implemented in respect to equity, inclusion, and or diversity?
10. How do you implement Board policies on equity, inclusion, and or diversity into your science program?
11. What is your opinion about the Ontario Ministry of Education's Science and Technology "program planning considerations"?
12. Tell me about how you use the program planning considerations in your science program?
13. What is your understanding of developing an "Antidiscrimination Science and Technology program" as outlined in the Science and Technology curriculum?
14. If you were going to implement antidiscrimination practices/processes in your science classroom, how would you do it?

15. In your opinion, what do you think is needed to support elementary educators in teaching diverse students science?

16. Is there anything you would like to add that hasn't been discussed?