Bridging the Gap between English Language Learners and Native English Speaking Students in Science Education

By
Reem Attia Karam Attia

A research paper proposal submitted in conformity with the requirements For the degree of Master of Teaching Department of Curriculum, Teaching and Learning Ontario Institute for Studies in Education of the University of Toronto

Copyright by Reem Attia Karam Attia, April 2016
Abstract

Ontario welcomes up to 100,000 immigrants every year. One in four students in Ontario schools are born outside of Canada. Research shows that the population of learners from diverse and non-English speaking backgrounds in the Ontario classroom is continuously growing (the Ontario Ministry of Education, 2007). The aim of this qualitative research project is to use a literature review and semi-structured interviews to explore how mainstream science teachers respond to the needs of English Language Learners (ELLs) in their classes, while reducing the already-present achievement gap observed between ELLs and their fluent English-speaking peers. This study also examines the varying instructional strategies used by mainstream science teachers to overcome any obstacles that arise in terms of delivering effective scientific teachings to ELLs. The main question guiding this research is: “How do mainstream classroom science teachers facilitate the learning of the English language along with the disciplinary knowledge in science for their ELLs?”

Data was collected through semi-structured interviews with three science teachers/educators from Toronto schools. Findings showed how these teachers/educators are attempting to integrate ELLs into their science classes, and spoke to the varying challenges they face in terms of assessment, as well as the outcomes observed of ELLs. The implications of these findings suggest that more needs to be done in order to support pre-service and in-service teachers who teach science to ELLs, along with the integration of more effective support systems by ministries of education and school boards.

Keywords: ELLs, Science, Education, Elementary, Secondary, Education Gap
Acknowledgements

First and foremost, I would like to thank my mother and my father for providing me with the opportunity to continue my higher studies here in Canada. Without their unconditional love, constant support and motivation, none of this could have been possible. Thank you, Mama and Baba, from the bottom of my heart.

I would also like to thank my research participants. Their willingness to participate and share their experiences and insights was the reason I was able to write this paper.

I extend my heartfelt thanks to Dr. Angela MacDonald-Vemic and to Dr. Rodney Handelsman for their care and guidance throughout my experience writing this paper. I feel extremely fortunate to have been blessed with the opportunity to work with these two dedicated and remarkable professors.

Last, but most definitely not least, I would like to thank my classmates—the Fanciest cohort ever—for their continual positive attitudes and support throughout our two years together in the Master of Teaching program. Stay Fancy.
# TABLE OF CONTENTS

Abstract ......................................................................................................................... 2  
Acknowledgements ........................................................................................................ 3  

CHAPTER 1: INTRODUCTION ......................................................................................... 6  
1.0 Introduction to the Research Study ........................................................................... 6  
1.1 Research Problem .................................................................................................... 7  
1.2 Purpose of the Study ............................................................................................... 8  
1.3 Research Questions ................................................................................................. 8  
1.4 Background of the Researcher ................................................................................ 9  
1.5 Overview ................................................................................................................ 10  

CHAPTER 2: LITERATURE REVIEW .............................................................................. 11  
2.0 Introduction ............................................................................................................ 11  
2.1 Challenges faced by ELLs in Mainstream Classrooms: ......................................... 11  
2.2 Why is Science education a problem for English Language Learners? .................. 12  
2.3 The Importance of Science Education and Instruction to English Language Learners.... 17  
2.4 The Role of Teachers in Teaching Science to English Language Learners ............. 20  
2.5 Strategies for English Language Learners’ Science Education and Instruction ......... 21  
   2.5.1 Instructional Strategies ....................................................................................... 22  
2.6 Conclusion ................................................................................................................ 23  

CHAPTER 3: RESEARCH METHODOLOGY .................................................................. 25  
3.0 Introduction ............................................................................................................ 25  
3.1 Research Approach & Procedures ......................................................................... 25  
3.2 Instruments of Data Collection .............................................................................. 26  
3.3 Participants ............................................................................................................. 28  
   3.3.1 Sampling Criteria ............................................................................................... 28  
   3.3.2 Sampling procedures ......................................................................................... 29  
   3.3.3 Participant Bios ................................................................................................. 30  
3.4 Data Analysis .......................................................................................................... 31  
3.5 Ethical Review Procedures ....................................................................................... 32  
3.6 Methodological Limitations and Strengths ............................................................... 33
3.6.1 Methodological Limitations

3.6.2 Methodological Strengths

3.7 Conclusion

CHAPTER 4: FINDINGS

4.0 Introduction

4.1 Participants’ acknowledgement of the presence of an achievement gap

4.1.1 Participants’ perceived reasons for the achievement gap

4.2 Teaching and learning challenges of science for English Language Learners

4.2.1 Challenges that ELLs face in learning science

4.2.2 Challenges that teachers face when teaching science to ELLs

4.3 Successful methods participants have used to help ELLs

4.3.1 Teacher efforts to create a safe and welcoming environment for ELLs

4.3.2 Strategies to teach science to ELLs

4.3.3 Human and material resources used to support ELLs

4.4 A Tension between Equality versus Equity in assessment and outcomes of ELLs

4.4.1 Assessing learning needs

4.4.2 How learning is evaluated

4.4.3 The observed outcomes

4.5 Conclusion

CHAPTER 5: IMPLICATIONS

5.0 Introduction

5.1 Overview

5.2 Implications

5.2.1 Broad Implications

5.2.2 Narrow Implications

5.3 Recommendations

5.4 Areas for further research

5.5 Concluding comments

REFERENCES

APPENDICES

Appendix A: Letter of Consent for Interviews

Appendix B: Interview Protocol
CHAPTER 1 - INTRODUCTION

1.0 Introduction to the Research Study

Upon arrival to Toronto, I was very surprised to see the vast diversity of people around me. It seemed like every other person was from a different cultural or ethnic background. Upon investigating, I was shocked to find out that Ontario welcomes up to 100,000 immigrants every year and that one in four students in Ontario schools was born outside Canada. This sparked my interest in my research topic, as I felt that because of these vast numbers, there would also be a correlating number in English Language Learners (ELLs) in the mainstream Canadian classroom.

Because of these rapidly changing demographics, the Canadian classroom is a highly diverse one, filled with learners whose linguistic abilities span a broad range of capabilities. In order for these newcomers to be integrated into the mainstream classroom successfully, they must face and overcome several challenges, including adapting to the linguistic, sociocultural and academic norms and practices in content areas (Duff, 2001). Because of the great variety in ELL’s learning and academic needs, it is important for teachers and educators to develop strategies that ensure academic achievement and promote equity for ELL students (Lee, 2008). Although this need exists across the different disciplines, it is particularly critical in science education, where achievement gaps between mainstream, fluent English-speaking students, and non-mainstream students, such as ELL students whose first language is one other than English, have persisted over several decades (Campbell, Hombo and Mazzeo, 2000). According to research, this problem exists for several reasons: firstly, teachers expect their students to have learned English, or mastered it rather, before learning science; secondly, the fact that most elementary teachers are not sufficiently prepared to teach science effectively; and finally, the unfortunate truth that today’s teachers are poorly equipped to meet the learning and academic needs of linguistically diverse (ELL) students.
in science instruction. Therefore, closing the achievement gaps among linguistically-diverse student groups, while improving the science achievement of all students, should be seen as concurrent goals for science educators (Lee, 2008).

### 1.1 Research Problem

The population of learners from diverse and non-English speaking backgrounds in the Ontario classroom is continuously growing (the Ontario Ministry of Education, 2007). As of 2013, records show that about 8% of students in elementary schools and 4% of students in secondary schools are identified as ELLs. According to Lee and Fradd (1998), “Science has been traditionally taught with the expectation that students will understand and learn when teachers present the content in scientifically appropriate ways” (p. 12). The resulting lack of acknowledging students’ literacy, language and cultural understandings has contributed to the alienation of ELL students in science, which in turn correlates with a drop in their academic achievements. Although there is scarce literature on science inquiry with students whose first language is not English, the existing literature on general instructional approaches offer promising possibilities (Lee & Fradd, 1998).

Because the vocabulary used in science class is usually very specific and not frequently used in other subjects/disciplines, there is a compelling need to bridge the educational language gap that results between students whose first language is not English, and those whose first language is English, to achieve effective instruction in the science classroom. According to research, in order for ELLs to avoid falling behind their fluent-English-speaking peers in academic subjects such as science, they need to develop English language and literacy skills simultaneously (Lee, 2005).
1.2 Purpose of the Study

The purpose of this study is to learn how mainstream classroom science teachers are responding to the needs of their ELLs through instructional approaches that simultaneously facilitate their learning of English and disciplinary knowledge in science. I am interested in learning how these teachers identify the various needs of their ELL students and consequently use varying instructional strategies to overcome any obstacles that may have arisen in terms of delivering effective scientific teachings. This is extremely important to the education community to guarantee educational equity and inclusivity throughout the Canadian schooling system.

1.3 Research Questions

The main question guiding this research is:

- How do mainstream classroom science teachers facilitate the learning of the English language along with the disciplinary knowledge in science for their ELLs?

Subsidiary questions include:

- What strategies (e.g. Differentiated Instruction) do teachers use to facilitate the conceptual learning of ELL students in science class?
- How do these teachers assess the learning needs of the ELLs?
- How do these teachers evaluate the learning outcomes of their ELLs in the context of expectations set forth in the science curriculum?
- What outcomes do these teachers observe from their ELLs in terms of their disciplinary knowledge of science?
- What challenges do these teachers experience in responding to the needs of their ELLs and how do they confront these challenges? What factors and resources support them?
1.4 Background of the Researcher

Being a science teacher in Cairo, Egypt, for 5 years before commencing my Master’s at the University of Toronto, I was continuously exposed to, and reminded of, the fact that my students were ELL students. Being a native English speaker myself, I could not relate to their evident struggle to grasp and comprehend the scientific vocabularies and terminologies associated with and significant to science education. I found myself struggling to come up with an assortment of strategies that would deliver the information and concepts to the ELL students without resorting to the use of their mother-tongue (Arabic). I also recognized the boredom/frustrations of the few, yet still sometimes present, fluent English speakers in class, when the ELL students took longer to establish the connections that they themselves had made so rapidly just because of their superior linguistic abilities. Although not very prevalent, but I could see the emergence of a gap and a loss of inclusivity between the students in my science class.

Upon coming to Canada, I realized that there was a very similar problem existing in the Canadian classroom, simply due to the fact that Canada is a multi-culturally diverse country. There are a lot of ELL students in Canadian schools and the gap between them and their fluent English-speaking classmates is even greater than the gap I left back home in Egypt. I am extremely interested in exploring how science teachers in Canadian classrooms address the different linguistic abilities of their ELL students during science class, while maintaining the sense of inclusivity and equity throughout the process. Also, how they are able to sustain the interest and engagement of the students in their class whose first language is English, is a key aspect that I am looking forward to discovering. I believe that this topic will be of great assistance to me both during my practice teaching as well as when I begin my professional career as a teacher in Canada.
1.5 Overview

Chapter 1 includes the introduction and purpose of the study, the research questions, as well as how I came to be involved in this topic and study. Chapter 2 contains a review of the literature, looking specifically into the varying instructional approaches used by teachers in science class to ensure ELL students’ inclusivity and comprehension of material covered. Chapter 3 provides the methodology and procedure used in this study, including information about the sample participants and data collection instruments. Chapter 4 identifies the participants in the study and describes the data as it addresses the research question and subsidiary questions. Chapter 5 discusses the implications of the study, conclusions, recommendations for practice, and possible areas for further research. References and a list of appendices follow at the end.
CHAPTER 2 - LITERATURE REVIEW

2.0 Introduction

This project explores the reasons behind the growing educational gap observed in science education between non-native English speakers, referred to in this paper as English Language Learners (ELLs), and their native, fluent English-speaking peers. It also intends to ascertain the different pedagogies, methodologies and differentiated instructional approaches used by science educators and teachers to successfully bridge this gap. This chapter examines the challenges ELLs face in a mainstream classroom, the reasons for science education being problematic for English Language Learners, the importance of effective science instruction to such learners, the roles of teachers in teaching science to students who are linguistically diverse, and strategies that are designed to overcome educational barriers faced by English Language Learners.

2.1 Challenges Faced by ELLs in Mainstream Classrooms

A great amount of literature addresses the plethora of challenges English Language Learners face when placed in a mainstream classroom. The discomfort of being in a foreign and unfamiliar environment is only augmented by the anxieties that stem from struggling with a new language. According to research, “Language shock is [perhaps] the most common phenomenon that language learners experience when adjusting to their new environment” (Miller & Endo, 2004, p. 787). The anxiousness created by language shock, a student’s inability to communicate effectively, also affects the academic performance, especially when trying to learn a new language, as the student experiences a drop in motivation and self-esteem (Krashen, 1982). English Language Learners are also often subjected to mockery by peers, which exacerbates their feelings of anxiety.
Because the curricula in the Western world are usually Euro-centric and quite different from other curricula, research points to ELLs experiencing a heavy “cognitive load.” This occurs when ELLs are unable to relate to the material they are being presented with and thus adds on the already pre-existing language difficulties they are experiencing (Miller & Endo, 2004).

“Cultural load” is another pedagogical problem that English Language Learners have to face. Not only do they need to learn the meanings of new words, but they also have to understand their proper cultural contexts and usages. These aspects are usually overlooked by ELLs’ peers and teachers and only adds to ELLs’ struggles and frustrations (Miller & Endo, 2004).

2.2 Why is Science Education a Problem for English Language Learners?

It has become evidently clear in the recent years that the educational gap in science achievement between native-English speaking and non-native English speaking students is increasing at an alarming rate (Lee, 2005; Garza, Kennedy & Arreguin-Anderson, 2014). According to Lee (2005) “International and national studies on science achievement indicate poor science performance…and persistent achievement gaps between mainstream students and nonmainstream students” (p. 492). This indicates that there is an urgent need for novel pedagogies that overcome any existing barriers between content and language so that all students can learn science as well as acquire English.

There is vast amount of literature that addresses the reasons why science education has proven to be particularly challenging to students who come from linguistically diverse backgrounds. The literature repeatedly points to the lack of both teacher knowledge and institutional support in addressing the educational needs of ELLs (Lee, 2005). This is particularly concerning because it is established that in order for students to have a high-quality learning experience, regardless of their cultural or language background, it is the responsibility of their
teachers to have the content knowledge and “know-how” to meet the learning needs of these students. Research has shown that most elementary teachers are inadequately prepared to teach science since they usually lack both the content knowledge as well as the familiarity with inquiry-based science instruction (Loucks-Horsley, Stiles, Mundry, Love & Hewson, 2009; Buxton, Lee and Santau, 2008; Kennedy, 1998). According to research by Kennedy (1998) and Loucks-Horsley et al. (2009), “It has been well documented that most elementary teachers are not adequately prepared to teach science effectively, as they frequently lack both the science content knowledge and the familiarity with inquiry-based science instruction needed to teach reform-based science” (Buxton, Lee and Santau, 2008, p. 496). This points to discrepancies in the level of science teachers’ aptitudes and how adequately prepared they are to properly instruct young students in content subjects especially those such as science. Buxton et al. (2008) continue to state that “Most of our practicing teachers, however, had not themselves learned science through hands-on inquiry and had some reservations about teaching in this manner” (p. 497) and Lee (n.d) states “Additionally, they are not sufficiently prepared to meet the learning needs of ELLs” (p. 9) clarifying the reasons as to why science teachers struggle with the delivery to their ELL students.

Another interesting reason for the growing gap in science capabilities between English Language Learners and their mainstream peers is the unfortunate fact that schools tend to focus on the proficiency levels of the students in subjects such as English literacy and numeracy at the expense of other content subjects such as science (Buxton et al., 2008). Lee (n.d) also found that “Instructional time for science in elementary schools is often limited and tightly regulated due to the urgency of developing basic literacy and numeracy in students with limited literacy and numeracy skills and those learning English as a new language” (p. 3). This problem is also articulated by Amaral, Garrison and Klentschy (2002):
In the effort to better meet achievement expectations, many districts have chosen to focus on reforms that target “the basics.” This is usually interpreted to include reading, writing, and mathematics. Unfortunately, this is often done at the expense of other subject areas, such as science. (p. 214)

Lee, (n.d) found that “Content area instruction for ELLs is often treated as secondary to language instruction” (p. 9) which should be of great concern to all educational professionals because we have come to see the importance of attaining content objectives simultaneously with language objectives. This means that when educating non-native English Language speakers in content subjects such as science, it is vital to maintain language objectives at the same time. According to the literature, the implementation of dual goals/objectives not only ensures content-knowledge achievement, but also allows the teacher to scaffold the student’s English language learning skills.

In their research, Amaral et al. (2002) spoke to several teachers about the difficulties they faced when teaching science to English Language Learners. They found that most of the hindrances were attributed to problems with student retention, lack of support from home/parents/guardians and limitations of students’ basic academic skills (Amaral et al., 2002). This sheds light on how and why teachers perceive English Language Learners to struggle in science education. It is suggested that what also contributes to the struggles is the fact that in some schools, there is a mobility rate among both teachers and students (Amaral et al., 2002). This could lead to the conclusion that schools should try to implement methods of reducing teacher mobility, at least, in order to effectively increase the instructional time that the students receive from their teachers.

According to Lee (n.d), “Hands-on, inquiry instruction relies heavily on supplies and equipment” and that “Many elementary classrooms lack appropriate science instructional materials
and supplies” (p. 3). These are also important factors that should be considered when trying to unravel the mystery that is why science education to English Language Learners is such a feat. If school administrations were to place more emphasis on the availability of appropriate resources and materials, this would allow teachers to provide rich and engaging science lessons for their students. It is understandable that some teachers might feel the urgent need and pressure to focus on test preparation for other subjects such as mathematics, rather than on inquiry-based science teaching (Amaral et al., 2002). However, this does not mean that teachers should not pay more attention to different methods and strategies, such as hands-on inquiry-based science instruction, to meet the requirements of all content subjects in the classroom.

Much of the literature on language acquisition has shown that the language used by ELLs is usually conversational English, which is quite different from the more demanding and academic English that is required in science classes (Allan & Park, 2011). This, unfortunately, points to another cause as to why teaching science to English Language Learners is proving to be an increasingly distressing issue for teachers. According to Lee (n.d) “Many teachers assume that ELLs must acquire English before engaging in content area learning” (p. 9). This is quite problematic as research has shown that there is a large difference between normal conversational English and scientific English. Allen and Park (2011) refer to Carrier’s note (2005) on how “The cognitive academic language proficiency (CALP) [of ESL students] takes five to seven years to fully develop” (p. 30). This is an important issue for science teachers of non-native English Language Learners to consider. They have to bear in mind that, although they might assume that their ELL students can converse with them and their peers appropriately, that this does not necessarily mean that they will be able to fully comprehend and contextualize scientific information in science class.
The lack of teachers who come from diverse backgrounds as well as those who are willing to teach for diversity is also a major contributing factor to the growing gap in science education for students from diverse linguistic backgrounds. Fraser-Abder (2001) states:

> Because the proportion of minority students in the school system is not reflected in the number of minority teachers, few teachers come to the [urban] classroom with an in-depth understanding of the cultural contexts that inform their students’ perspectives on schooling, learning and science. (p. 126)

The availability of teachers who are aware of the importance of cultural diversity and understandings of their students would most likely contribute significantly to the learning experience of English Language Learners across all school subjects, not only in science. When discussing the lack of teacher consideration for diversity, there is a direct link to the reason that ELLs tend to fall behind their English-speaking peers (Buxton et al., 2008). The capability of a teacher to recognize and respect the value of the languages and cultures that the different students bring to the learning environment and learning process is imperative to creating and maintaining a safe, inclusive and stimulating classroom environment where instructional harmony and teacher support will assist students in relating to science (Lee & Fradd, 1998).

Teachers also must be willing to exert extracurricular effort and allow non-native English Language speaking students extra time to assimilate information, complete their thought processes and decipher scientific implications (Vang, 2006, p. 37). This is because English Language Learners usually require more time to think about what it is they want to say, as well as how they want to say it. The importance of allowing the students this extra time can make all the difference for them, as it is often the differentiating factor between perceived success and failure.
As mentioned above, there is a vast range of reasons for science education being problematic for English Language Learners. These students have a variety of educational needs and requirements, which makes them more vulnerable to discontinuities and more likely to fail in keeping up with their English-speaking peers (Buxton et al., 2008). However, it is my belief, which is also supported by the large amount of research in the area, that these obstacles can be overcome with the installation of proper policies and resources in schools, both in terms of material resources, as well as appropriate teacher-education approaches.

2.3 The Importance of Science Education and Instruction to English Language Learners

Looking at all the research there is in this area, it is needless to say that the growing educational gap between English Language Learners and their native English speaking peers is a growing concern. This is not only because of equity issues, but also due to the fact that language should never be a barrier in any child’s educational experience. Under this heading, I discuss the research on the importance of proper and effective science education and instruction to English Language Learners.

Amaral et al. (2002) state that “Science is essential for developing student thinking. Science also provides a context in which students can continue to develop reading and writing skills as well as mathematics” (p. 214). They point to the important skills that students can develop through their science education. This is further clarified in their work as they discuss the benefits of inquiry-based science for English Language Learners. Inquiry-based science encourages students to explore and through this process of exploration students have chances to discuss and learn about the context for content learning, rather than rely on text-heavy material. Inquiry-based science lessons allow non-native English speaking students to learn from each other and their classmates by observation and exploration, taking the weight off academic language that they are
still coping to learn (Amaral et al., 2002). Another benefit of inquiry-based science for English Language Learners is that it builds their thinking skills and does not require them to exert a lot of energy on language, as a greater focus is on the ideas and concepts being learned. When working cooperatively in pairs or small groups during science classes, ELLs are able to develop and practice their expressive skills and build their vocabulary. During hands-on group activities, students may feel a greater level of comfort in working with their peers, rather than passively receiving instructions from a teacher (Amaral et al., 2002).

According to Lee (n.d.), “Nonmainstream students frequently bring values and practices to the classroom that can be seen as continuous with science inquiry practices, especially if the teacher is attuned to this possibility and adopts strategies to highlight such continuities” (p. 6). He describes how lessons rich in scientific inquiry promote thinking and reasoning that involve both literacy and science learning:

Language functions (e.g., describing, hypothesizing, explaining, predicting, and reflecting) develop simultaneously with science inquiry and process skills (e.g., observing, describing, explaining, predicting, estimating, representing, and inferring). In this sense, science inquiry promotes thinking and reasoning that involves both literacy and science learning. (Lee, p. 7)

In further research, Cuevas, Lee, Hart and Deaktor (2005) expand on the opportunities that inquiry-based science instruction and learning provide for non-mainstream students of linguistically diverse backgrounds. Findings show that science inquiry promotes the development of important analytical skills such as problem solving, communication and thinking skills that are essential for the development of any student into a competent and contributing member of society in the 21st century.
Further research by Lee (n.d.) also found that “Hands-on activities are less dependent on formal mastery of the language of instruction and, thus, reduce the linguistic burden on ELLs” (p. 10). This attributes to the importance of proper achievements in a subject such as science, where the focus should be on the student’s concept and content attainment, rather than on his or his form of language use. Focusing on hands-on science activities and inquiry-based learning allows English Language Learners the chance to develop their social language, which in turn leads to the development of academic learning. This way, students can advance in areas of logic, reasoning and critical thinking. These skills are essential for both literacy and science. (Lee & Fradd, 1998).

Science education also allows English Language Learners to develop their mathematical skills. Students apply mathematical concepts such as measuring properties of objects and events, recording and presenting data in different formats and identifying patterns (Lee, 2005). This attests that science education is important for the development of a wide range of essential skills that students need, as well as benefiting them in other subjects they take at school.

Moore (2007) asserts that “If students do not develop English language skills in the science classroom, along with learning science and Literacy skills, then they are further marginalized from learning science, participating in the culture of science, and acquiring the language and culture of power” (p. 335). This, once again, stresses the importance of having dual goals/objectives in the science class, one addressing the content and the other addressing the language, as discussed earlier. This way, teachers can ensure that their non-native English Language speaking students progress in both areas, science as well as language proficiency, and avoid losing their students’ interest in science education.
2.4 The Role of Teachers in Teaching Science to English Language Learners

Teachers who teach science to English Language Learners play a central role in the experience these students have in the classroom. It is important to always remember that students who come from linguistically-diverse backgrounds are most likely to be experiencing a range of feelings and emotions, struggling with new foreign content, language, cultural and social norms. It is the responsibility of the teacher to ensure that the student adapts and fits in to their new environment successfully. The fact that, as discussed earlier, some teachers do not feel it is their responsibility to acknowledge and incorporate their students’ diversity is something that needs to change in the educational system. According to Fraser-Abder (2001),

To better facilitate learning, teachers must be familiar with the learners’ environment as well as the learners’ socio-cultural background. Teachers must be sensitized to the needs and feelings of their students, they must understand the cultural backgrounds and the contributions each student can bring to the classroom. (p. 130)

Lee (n.d.) also emphasizes the importance of “providing instructional scaffolding that integrates the students’ cultural and linguistic experiences with scientific practices” (p. 10). Teachers should be able to make connections between the students’ prior knowledge and scientific practices and use these connections as the basis for instructional practices (Cuevas et al., 2005).

Some teachers struggle because of the great amount of state accountability systems in place which force them to neglect the needs of their non-English speaking students. However, teachers should try to look beyond these hindrances and focus on the academic progression of their students. They are encouraged to engage their ELL students in a range of group formations so that the students learn how to communicate independently, in small groups as well as with the entire
class (Buxton et al., 2008). Teachers must also recognize the opportunities when to use students’
home language in science instruction, allow the students to collaborate in the language they feel
comfortable with and also allow them to share cultural artifacts, culturally relevant examples in
order to facilitate the students’ experience in science class (Buxton et al., 2008). To add on to this,
research by Lee and Fradd (1998) clearly articulates the expectations of a science teacher who
teaches students from non-English-language-backgrounds:

Science learning requires that teachers have (a) an understanding and
appreciation of students' language and cultural experiences, (b) scientific
knowledge and habits of mind, and (c) abilities to relate science to students'
background experiences. (p. 18)

In other research, Vang (2006) also discusses the important role of the teacher. He states “Science
teachers must develop teaching methods that enable Limited English Proficient students to excel in
the sciences despite their language deficits” (p. 40). He continues to elaborate on this point,
stressing on how teachers should allow students to develop their own modes of representing their
knowledge, translating scientific knowledge into actions and expressing their understanding
through experimental experiences.

2.5 Strategies for English Language Learners’ Science Education and Instruction

In this section, I attempt to dissect the immense amount of literature that discusses the
different strategies that are beneficial for the science education of English Language Learners.
According to Garza el al., (2014) “The usefulness of a strategy depends on the needs of the
learners and their understanding of how to apply it in the learning process” (p. 502). This means
that enough information about the students’ learning preferences needs to be assembled in order to
implement the effective strategies that will benefit them and aid them in understanding how to use the strategies in their learning experiences.

2.5.1 Instructional Strategies

According to Lee and Buxton (2010) “There are instructional strategies that are pivotal for science learning such as the activation of prior knowledge, the use of graphic organizers, the inclusion of science trade books, and comprehension of language functions in relation to science process skills” (Garza et al., 2014, p. 498). They also refer to the use of hands-on activities, realia and cognates to assist in science concept development and reduce the amount of time an English Language Learner would spend learning new science vocabulary (Garza et al., 2014).

Other research points to the use of visuals, such as bulletin boards in an easily accessible place and vocabulary lists included in students’ science notebooks (in the form of a glossary) as effective instructional strategies that benefit non-native English Language students (Amaral et al., 2002). Amaral et al. (2002) also reference “the time provided for students to share their experiences and findings orally gives English learners great opportunities to use expressive skills for academic language” (p. 236). The importance of output opportunities and use of effective wait time, like mentioned earlier, are repeatedly showing to be strategies of importance in science instruction for English Language Learners.

Buxton et al., (2008) advocate the use of multiple modes of communication and representation to improve students’ understanding of science. They also stress the significance of using linguistic scaffolding to promote ELL students’ comprehension of science and the engagement of students in different group formations that allow them to communicate in different dynamics, such as independently, in small groups or with the whole class (Buxton et al., 2008).

Allen and Park (2011) found that four instructional strategies that appeared to be effective
in supporting English Language Learners’ science learning were (p. 6):

1. Use of a worksheet that employs simpler language in a sentence frame,
2. Use of pictorial materials,
3. Use of peer interpreters, and
4. Altered assessment tools such as drawings and individual interviews.

This literature review on the different instructional strategies that are designed to help English Language Learners would not be complete without recognizing a few more helpful strategies such as adjusting the language load used by teachers to encourage the participation of the students, such as enunciating, reducing difficult language to key vocabulary and using simplified sentence structures (Buxton et al., 2008).

2.6 Conclusion

The purpose of this paper is to explore how science teachers facilitate the learning of English Language Learners in their classes, accommodate their varying needs while ensuring the engagement and involvement of the other mainstream students and consequently bridging the educational gap in science between these two groups of students.

The literature has shown that there is indeed a reason to be concerned about the growing gap between non-native English speaking students and English speaking students as well as how imperative proper science education for students from a diverse linguistic background is. The role of the teacher has been thoroughly explored and it can be concluded that teachers need to begin incorporating the English Language Learners, along with their culturally diverse backgrounds and experiences, into the classroom. Teachers also need to exert more effort into applying the strategies that have proven to be effective for non-native English speaking students, consistently.
There is a great deal of research in this area, and I do believe that future researchers should focus on the actual results of implementing specific strategies to help aid English Language Learners to be on par with their peer native English Language speaking classmates.
CHAPTER 3 - RESEARCH METHODOLOGY

3.0 Introduction

In this chapter I describe the research methodology used to explore the presence of an educational gap and the range of strategies used by classroom teachers to effectively integrate English Language Learners into a science class, without aggravating the educational gap between them and their fluent English speaking peers. I begin by reviewing the general approach, procedures, and data collection instruments, before elaborating more specifically on participant sampling and recruitment. I explain how the data is analyzed and assess any ethical considerations related to my study. I also consider any methodological limitations, while looking into the strengths of the methodology. The chapter is concluded with a summary of key methodological decisions and the rational for these decisions given the research purpose and questions.

3.1 Research Approach and Procedures

This research study was conducted using a qualitative research approach which involved examining the pre-existing literature in the field to create a literature review and is accompanied by semi-structured, face to face interviews carried out with three participant teachers who met the prerequisite criteria.

Ritchie, Lewis, Nicholls and Ormston (2013) describe qualitative research as “a naturalistic, interpretative approach concerned with understanding the meanings which people attach to phenomena (actions, decisions, beliefs, values etc.) within their social worlds” (p. 3). Because the overarching aim of qualitative research is to provide in-depth understanding of a particular scenario or situation in the social world, the researcher often makes knowledge claims with the intent of developing a theory or a pattern (Ritchie et al., 2013; Creswell, 2013). Given my
research purpose of exploring how mainstream classroom teachers respond to the needs of English Language Learners through differentiated instructional approaches that simultaneously facilitate their learning of English and disciplinary knowledge in science, the qualitative research approach is the most appropriate approach for this study, as I am seeking to achieve a better understanding of a social situation and educational reality, from the point of view of the people who are involved (Flick, von Kardorff & Steinke, 2004). This is due to the methodological stances associated with qualitative research, which include the perspective of the researcher and the researched, the nature of research design, the descriptive nature of data generated and of the research methods used, the inductive nature of analysis/interpretation as well as the nature of outputs (Ritchie et al., 2013; Bogdan & Biklen, 1997). These stances allowed me to adopt a flexible research strategy while conducting in-depth individual interviews, the process of which is discussed further in the upcoming section, in real-world settings and identify and explore emergent themes from the data collected. Equally, because qualitative research is iterative, one in which there is constant revisiting and revising of design and implementation to ensure the cohesion between question formation, literature and data collection and analysis (Morse, Barrett, Mayan, Olson & Spiers, 2002), this allowed me to constantly re-mold and re-shape my findings according to developing themes that arose.

3.2 Instruments of Data Collection

In this study, the primary instrument of data collection was the semi-structured interview protocol. Semi-structured interviewing was selected because it is a verbal interchange where the interviewer attempts to gather information from the interviewee participants while allowing them to explore arising issues and ideas that they feel might be of importance (Longhurst, 2003). According to Miles and Gilbert (2005) “the flexibility of semi-structured interviews makes them
so well suited to answering a ‘why’ question. By changing the questions and the areas discussed during the interview we can address aspects that are important to individual participants, and by doing so we can gain a better understanding of the research question.” (p. 66). Although questions are prepared in advance to address a specific topic, the nature of semi-structured interviewing allows space for the participants to offer new meanings to the topic of study since they are able to elaborate on their experiences, thoughts and feelings (Galletta, 2013; Milles & Gilbert, 2005). This interviewing method was ideal for my study as I was relying heavily on the in-class experiences of science teachers and how they identify the scientific educational needs of their ELLs and use effective strategies and instructional approaches to bridge any emerging gaps between the ELLs and fluent English speaking students. The use of semi-structured interviews was also critical in such a study as it allows for the engagement of the participants as well as any modifications to be made during the interview, depending on the interviewer’s perception of what seems to be important.

A semi-structured interview protocol was prepared in advance to provide structure for the upcoming interviews. According to Harrell and Bradley (2009), the development of an interview protocol is important for the formation of questions and probes that will be used in the interviews, allowing for the prioritization of the information wanted from each interview. It is also used to guide the interviewer in determining which questions are primary questions and which ones are secondary to the research purpose. The use of a semi-structured interview protocol in my study was appropriate because it helped guide me in the formation and precedence of my questions and probes to be used during the interviews, as well as in determining how long each question would be discussed (approximately) for as the interview time was rather limited. During each interview, I used a voice recorder to record the interview, which I transcribed shortly after completion.
3.3 Participants

In this section, I review the sampling criteria established for recruiting my participant teachers. Because I was looking for teachers who have been successful in integrating ELLs into mainstream science class without the creation of a gap between them and their native English speaking peers, I felt the necessity to interview exemplary teachers who would be able to provide me with the “know-how” of their strategies.

I have included a section for the introduction of each participant.

3.3.1 Sampling Criteria

The teacher participants were selected based on the following criteria:

- Teachers will be teachers who currently teach, or have recently taught, science at the intermediate level at the time of the interview;
- Teachers will be recommended as exemplary teachers in terms of their demonstrated commitment to supporting ELLs in the science classroom;
- Teachers will have a minimum of 5 years teaching science experience;
- Teachers will have recently had both ELLs and fluent English language speaking students in their class;

Rationale for criteria:

Teachers were to be teachers who teach, or had recently taught, science at the intermediate level at the time of the interview because I was interested in hearing current experiences and exploring the different pedagogies, methodologies and instructional approaches they use on a daily basis. They were to be recommended as exemplary teachers in terms of their demonstrated commitment to supporting ELLs in the science classroom because, as a beginning teacher, it was important for me to uncover the effective strategies used in science class to meet the educational
needs of a broad range of students. Teachers would have a minimum of 5 years teaching science experience, as it was important to establish that they had a significant array of experience in teaching the subject which would allow for the focus to be on the strategies used to meet the needs of ELLs in their classroom. Teachers would have recently had both ELLs and fluent English language speaking students in their class at the time of the interview - this was also to ensure that the stories shared and data collected would be current and relevant. They would be willing to be involved in the research project and willing to share their insights and experience as this would also contribute to the quality of the answers and information shared during the interview.

### 3.3.2 Sampling Procedures

Research shows that there are various forms of sampling techniques that are used in qualitative research studies. I looked into purposeful and convenience sampling techniques. The first form that is visited here is purposeful sampling. According to research, purposeful sampling is used to answer questions about a certain matter by deliberately selecting individuals or groups of individuals based on specific purposes related to answering a research study’s questions (MacNealy, 1999; Teddlie, & Yu, 2007). Teddlie and Yu (2007) state that this sampling technique is used to achieve representativeness or comparability when “the researcher wants to select a purposive sample that represents a broader group of cases as closely as possible” (p. 80).

Convenience sampling, on the other hand, is the technique in which sample participants are both easily accessible and willing to participate in the study (Higginbottom, 2004; Teddlie & Yu, 2007). Although convenience sampling is not adequate in every situation, it can provide an acceptable sample in many situations, however, one must bear in mind that some amount of effort will likely be involved in reaching and recruiting participants. Also, convenience sampling allows the researcher a level of access to and familiarity with the sample that guarantees a richness of data.
that could not be attained if the sample were less familiar, and therefore less convenient. The most important possible pitfall in using this technique is that because the subject matter or population being studied is likely to be quite familiar, the researcher might be tempted to generalize beyond this narrow population. It is important that the researcher should be especially careful not to overgeneralize (Koerber & McMichael, 2008).

Because of its distinctive characteristic of providing rich data from easily accessible and willing participants, and the fact that I was immersed in a community of fellow teacher candidates, colleagues and mentor teachers, I used the convenience sampling technique for this study. I asked for referrals from fellow teacher candidates and professors (specifically professors with expertise in the science education field) as well as contacted teacher associations, such as the STAO, school boards and principles (with whom I have had the opportunity to work during my previous practicums) to recruit the most appropriate participant teachers. I provided them with an overview of my research as well as the participant criteria mentioned above. Accordingly, I asked these individuals to distribute my information to teachers who they believed may fulfill the criteria. Once this was done, I provided my contact information, rather than ask for the names and contact information of the recommended participants. Doing this helped ensure that teachers were volunteering to participate rather than feeling any pressure or obligation to participate.

3.3.3 Participant Bios

Peter was in his fourth year at the school he was teaching in at the time of the interview. He taught grade 8 homeroom English and Math. He also taught grade 8 rotary science to two homeschool classes and a gifted class. Throughout his teaching career Peter had also taught Art, Physical Education and English to French immersion students. In total, he had taught 7 years of intermediate science.
Louise had taught students in grade 9 to 12 science courses: grade 9 applied academic locally developed courses, grade 10 academic applied locally developed courses, grade 11 biology, grade 11 chemistry, grade 12 university biology and college chemistry. Overall, her teaching career spanned 15 years.

Daphne, who at the time of the interview was in a Long-Term-Occasional teaching position (LTO) for 5 years, also taught a range of science courses, ranging from grade 9 applied science to grade 11 university courses. At the time of the interview, she was teaching grade 11 environmental science and grade 11 university biology. Prior to the interview, she had taught grade 9 applied and academic, grade 9 ESL science as well as grade 10 applied and academic.

3.4 Data Analysis

Simon (2011) stated “Regardless of the chosen paradigm or methodology, data analysis is the process of making meaning from collected data” (p. 1). Qualitative data analysis involves working with, organizing, breaking down and synthesizing of data, while searching for patterns, discovering what is important and what is to be learned and told to others (Bogdan & Biklen, 1997). Because the challenge in qualitative analysis is to organize raw data into logical and meaningful categories as well as communicate the interpretation to others, this requires a significant amount of creativity on the researcher’s part (Simon, 2011; Bogdan & Biklen, 1997).

It is important to bear in mind that a “cyclical” approach of data collection must be maintained throughout this qualitative research study, one in which the data collection affects its analysis, which affects the formation of theory, since the main purpose is to understand rather than predict results (Westbrook, 1994). For my data analysis, I started out by transcribing the interviews. After that, I began coding the individually transcribed interviews, using my research questions as an interpretive tool, to identify categories of data, defined by Weber, 1990, as “groups
of words with similar meanings and/or connotations” (p. 37). I looked to identify similar themes within the emerging categories, whereas a theme refers to “clusters of categories that share some commonality such as reference to a single issue” (Westbrook, 1994, p. 246). Eventually, I made sense of the themes and how they mattered in relation to existing research, found and described in my literature review. I also looked into “null data”, with regards to what the interview participants did not speak about, and how/why this matters to my study.

3.5 Ethical Review Procedures

Before the interviews, the participant teachers were given letters of consent, (see Appendix A), which they were required to read and sign, as part of the interview process. This letter of consent allowed them to give their consent to being interviewed as well as audio-recorded, and provided an overview of the study, addressed ethical implications, and specified the expectations of participation (one 45-60 minute semi-structured interview). One copy of the letter of consent was given to each participant, and another copy was retained as part of the records for this research project. The interviews were conducted at places and times agreed upon by both myself and the participants. The participants were given all required information about the content, consent and confidentiality. All efforts to ensure their comfort and willingness to participate in the interview, as well as have the resulting data included in this study, was made.

To start off the interview, I reviewed my research topic with the participant. I informed him/her that they could choose to refrain from commenting on any question, review or revise their answers, or change their mind about the use of the data at any point in the research study. They were also informed of their right to withdraw from participation at any stage. All procedures were conducted in the same manner specified in the letter of consent and no changes were made to the procedures during the research and writing processes. The three participants’ names were changed
to pseudonyms to ensure their identities remained confidential and to avoid any situation or information that could compromise their anonymity. Any identifying markers related to their schools were excluded. The results of the study were reviewed by my course instructor before being finalized and each participant was made aware of, and consented to, my instructor’s role in the reviewing the data. It is important to note that were no known risks to participation in this study and that the participants had the opportunity to review the transcripts, to clarify or retract any statements, before data analysis was conducted. Finally, all data, including audio recordings, is to be stored on my password-protected laptop and will be destroyed after 5 years.

3.6 Methodological Limitations and Strengths

3.6.1 Methodological Limitations:

I recognize that the sample size that I worked with is very small, however, I believe it to be suitable given my research goal to explore how exemplary teachers ensure that ELLs in their science classes are integrated effectively, without the creation of an educational gap between them and their fluent English-speaking peers. Nevertheless, it is important to bear in mind that although interviewing such a small sample contributed findings that can inform my research topic, these findings cannot be generalized to all teachers who find themselves in comparable situations.

Furthermore, because of the ethical parameters that this research project has approval for, I was only be able to interview teachers, and not students and parents, and was unable to conduct surveys or classroom observations to assist in my data collection. However, because I was looking to discover how the teachers themselves deal with ELLs and avoid the creation of educational gaps in the science classroom between students of varied levels of English language mastering, I feel that the results and findings are appropriate for, and suffice, my research purpose and topic.

Additionally, given the time constraints of this research project, I carefully selected my 26
research questions that I felt would help me learn from this study. I also realize that the vast
majority of the literature in the field of catering to ELLs’ needs in a classroom is quite generalized,
and not specifically tailored to a science classroom. I, therefore, chose to focus my literature
review on writers and researchers whose work spoke specifically to my research goal.

3.6.2 Methodological Strengths:

Here I discuss the significance and benefits of using semi-structured interviews in my
study. According to Cohen & Crabtree, 2006, the use of semi-structured interviews “provides a
clear set of instructions for interviewers and can provide reliable, comparable qualitative data” (p.
1). It allows the preparation of questions ahead of time, which allows the researcher to be prepared
and competent during the interview process.

It also allows the participant teachers to express their views in their own terms, stressing on
what matters the most to them as well as allowing them the opportunity to reflect on their practice
and make meaning from their lived experiences.

The use of interviews also allows the researcher to seek very complete responses, where
depth of information is desired and useful (Harrell & Bradley, 2009). Furthermore, they are the
best methods to resolve “seemingly conflicting information, because the researcher has the direct
opportunity to ask” about the topic at hand as well as the emphasis placed on it, according to
Harrell and Bradley (2009).

3.7 Conclusion

In conclusion, this chapter served to provide information about the methodology used in
this research study. The main goal of this project is to explore the existence of, and the reasons
behind, the growing educational gap observed in science education between ELLs and their fluent
English-speaking peers. I was interested in looking into how mainstream classroom teachers use different pedagogies, methodologies and differentiated instructional approaches to overcome the challenges faced by ELLs in science class. In this chapter I have discussed the use of qualitative research approach and its significance. I described the procedures used, the data collection instruments (audio-recorded semi-structured interviews that were transcribed afterwards), the participant sampling criteria, as well as the recruitment process. How the data was analyzed has also been discussed. Ethical considerations and the methodological limitations and strengths have also been considered. In the following chapter, chapter 4, I report the research findings.
CHAPTER 4 - FINDINGS

4.0 Introduction

In this chapter I report and discuss the findings from three interviews that I conducted with junior/intermediate educators on their experiences and practices with English Language Learners (ELLs) in science class. All three educators exhibited sincere dedication to the successful integration of ELLs into a mainstream Canadian science classroom alongside their fluent English speaking peers. I use the data from the interviews to help answer my main research question to explore how mainstream classroom science teachers facilitate the learning of English Language Learners through instructional approaches that simultaneously facilitate their learning of English along with disciplinary knowledge in science, consequently reducing the achievement gap between the two student groups.

To protect their anonymity, I assigned my interview participants a pseudonym. Additionally, I have removed the names of any institutions, schools and/or school boards with which they are affiliated.

I have organized the findings into four overarching themes (and associated subthemes): 1) Participants’ acknowledgement of the presence of an achievement gap, 2) Teaching and learning challenges of science for English Language Learners, 3) Successful methods used to help English Language Learners and 4) A tension between equality versus equity in assessment and outcomes of ELLs.
4.1 Participants’ Acknowledgement of the Presence of an Achievement Gap

During the interview process, the participants were asked if they noticed any significant gap in the achievement of ELLs in science class in comparison with their fluent English speaking peers. Consistent with research conducted by Lee (2005) and Garza, Kennedy and Arreguin-Anderson (2014), all the participants confirmed the presence of such a gap. However, the participants’ reasons and explanations of this gap varied according to their experiences.

4.1.1 Participants’ Perceived Reasons for the Achievement Gap

When probed about his perceived reasons for the presence an achievement gap, Peter hesitantly attributed it to the students’ “cultural background”; He elaborated that “depending on the culture that the kids were coming from, and the support network at home, then yes there was a gap”. He continued to explain how he had observed that ELLs from certain cultural backgrounds had a more dedicated work ethic and tended to work “exceptionally hard to make sure that they understand”, whereas ELLs from other cultures tended be more hands-off and give up more easily. Thus, Peter attributed, these differences in achievement to the level of effort exerted by students based upon their cultural background. I found this very thought-provoking as it was something that I had not come across in the research of previous literature that I had carried out. Peter did, however, refer to the support network at home as a contributor to the ELLs’ performance level, which is in concert with the findings of Amaral et al. (2002), where most of the hindrances faced by science teachers of ELLs were attributed to a lack of support from home/parents/guardians. Interestingly, both Louise and Daphne repeatedly referred to the nationality and cultural background of the ELLs that they had
taught during their careers, however did not specifically attribute nationality and cultural background as causative factors of the achievement gap.

All three participants did, nonetheless, explicitly identify science’s subject-specific terminology as a major contributor to the achievement gap that they noticed between ELLs and their fluent English-speaking peers. Peter, Daphne and Louise explained how science, as a subject, is a very vocabulary and concept heavy one, and how usually scientific terms are used to define other scientific terms, which proves to be problematic for ELLs. I found that this converges with the research by Allan and Park (2011) who discussed the difference between conversational English and the more demanding and academic English that is required in science classes. Daphne also talked about how:

Science vocabulary itself is very Greek and Latin-centric, so they [ELLs] may not realize anytime they see the word *hydro* that it means water….you may have students who are coming from Europe, for example, who may be the children of immigrants, but because the vocabulary is based on European languages, they pick it up a lot easier than ELLs from various parts of Asia, where it’s a completely different root of the language so that’s where you can see a lot more of the difficulty.

This shows that students with different linguistic backgrounds may experience different challenges, or some may even have an advantage over others, when encountering new vocabulary, depending upon which languages they are already fluent in. This could be an indicator of the diversity that can be found within the ELL category which must be taken into account to improve instruction to support the students.
The literature by Buxton, Lee and Santau (2008) that discusses how most science teachers are not sufficiently prepared to meet the learning needs of ELLs coincides with the research done by Miller and Endo (2004) that deliberates the struggles ELLs face of not only learning new words but also understanding their proper cultural contexts and usages. On this, Louise deliberated on the importance of familiarizing ELLs with cultural contexts that are new to them before questioning them about it, saying:

We could be using loaded terms that are very culturally specific, one of the things we see is “Well when you travel up north to your cottage” and we make assumptions that all individuals have cottages in reference to astronomy, for example. Some kids have not been out of the city so they don't really know what the night sky looks like.

This indicates that not only do teachers need to be prepared to meet the challenges of teaching ELLs new words, but also to ensure that the students understand the cultural contexts in which the words are being utilized.

In addition, she discussed how the achievement gap depends on the age group being examined, explaining that it may be more evident in younger ages than in the more senior years where students may have been in the country for a longer period of time in which they had had the opportunity to practice the language. This is consistent with the literature on how the cognitive academic language proficiency (CALP) of ELLs takes five to seven years to fully develop by Carrier (2005) and how students who have been in the country for a longer time have had the chance to practice and improve their English fluency skills, thus reducing the achievement gap caused by an inferior English language ability.
Research by Fraser-Abder (2001) and Buxton et al. (2008) also shows a direct link between the lack of teachers from diverse linguistic backgrounds, who are aware of the importance of cultural diversity and understandings of their students, and the reason that ELLs tend to fall behind their English-speaking peers. This, in fact, is something that was deliberated during Daphne’s interview. She explained:

Both my parents are immigrants and my mother came here when she was 5 so I got to hear a lot of her experiences going through school as an English Language Learner, so I felt I had a little bit more insight, I guess, to it, than other people might.

Because Daphne has had this personal experience of what it is like to be an English Language Learner who is new to the country, it has allowed her to internalize the experiences and struggles than an ELL would face. As Daphne recognizes and respects the value of the languages and cultures that different students bring to the learning environment, this has ultimately helped her assist her ELL students in relating to science, which is in accordance to the research done by Lee and Fradd (1998). However, it is important to note that out of the 3 interview participants, Daphne was the only one who referred to this aspect.

4.2 Teaching and Learning Challenges of Science for English Language Learners

When discussing challenges of science education for ELLs, all three participants identified and spoke to a wide range of challenges. They addressed challenges that are faced by the ELLs, in general and in science class, and those that they themselves as science teachers who teach ELLs face. The following subthemes aim to respond to the subsidiary research question regarding the challenges that teachers experience in responding to the needs of the ELLs in their classes.
4.2.1 Challenges that ELLs Face in Learning Science

As discussed earlier, and perceived by all three participants to be one of the most prevalent causative factors for the achievement gap, the main challenge that ELLs face in learning science is the scientific terminology and vocabulary used. Daphne remarked:

I think one of the biggest ones [challenges] is the vocabulary, because some of them [ELLs] are coming in with that previous knowledge, but they can’t access it because they don’t have the vocabulary. The teacher is trying to access it, but we’re speaking the wrong language.

This, again, converges with the research carried out by Lee (2005) and Buxton et al. (2008) that speaks to the lack of teacher knowledge in addressing the educational needs of ELLs. Teachers who teach science to students from diverse language backgrounds, especially those who are still learning the English language, must attempt to “speak the same language” as their ELL students and use effective strategies to access the students’ previous knowledge to ensure that they are not exacerbating the already present achievement gap (Cuevas, Lee, Hart & Deaktor, 2005).

Also coinciding with the vocabulary challenge that ELLs face in science class are communication challenges. Louise discussed the importance of being mindful in her written communication with ELLs. She explained how she reduces the times where ELLs are required to read through an entire paragraph as that would lead to their “freezing up and they [ELLs] get nervous so they don’t really get the science”. Both Louise and Daphne spoke to the situations in which ELLs they have worked with in the past were able to understand more than they were able to communicate in English, which also points to the scientific vocabulary and its communication being a problematic challenge for ELLs. This is consistent with the research carried out by Carrier
Peter also pointed to the presence of another challenge that some ELLs may face in science: the fact that some ELLs may be learning science for the very first time in their lives. He said “I had a boy in my class last year, he had never had science before. So, not only was he learning English, he was also learning science for the very first time, too.” Although this situation of having an ELL student learning science for the very first time did not seem to be a common one among the research participants, it did give rise to the acknowledgment of yet another challenge: that some ELLs face in learning both scientific concept/content knowledge as well as a new language. Louise and Daphne also agreed that this is indeed a challenge most ELLs face and this mirrors the research done by Amaral et al. (2002) and Buxton et al. (2008), where the instructional time for science is often limited and often treated as secondary to language instruction instead of being simultaneous. This further reaffirms the importance of implementing the dual goals of both language and content. Further instructional scaffolding is necessary to integrate students’ cultural and linguistic experiences with scientific practices for the ELLs to ensure content-knowledge achievement as well as language learning (Lee, n.d.).

Yet another challenge faced by ELLs in science classrooms today was revealed by Peter. In several schools, ELL students are taken out for English Language support with an ESL teacher and then return to attend science class with their homeroom class and peers. This may be quite a daunting situation for an ELL who is still acclimatizing to many changes, including the time spent in and out of subject-specific classes. During my first practicum, I taught a grade 7 English ESL class and also had the opportunity to teach the same ELL students Health, and I remember their struggles in trying to keep up with their fluent-English speaking peers. Because the ELLs’ English
proficiency was still being developed, they struggled to communicate with their peers, comprehend the instructions and complete the tasks at hand.

4.2.2 Challenges that Teachers Face When Teaching Science to ELLs

The data from the three interviews generated a lot of insight into the challenges that teachers face when teaching science in general, but for the purposes of my research and this paper, I have chosen to focus on the challenges teachers face when teaching science specifically to ELL students.

Louise identified science’s heavy reliance on textbooks that use language that is “not appealing for English Language Learners and loaded terms that are very culturally specific” correlating with the findings of the research of Miller and Endo (2004) on the “cognitive and cultural load” problem that ELLs face. In this case, not only do ELLs need to learn new words—an entire new language, in fact—but also have to understand the proper cultural contexts and usages, which is something that is usually overlooked by teachers and peers.

Peter, Louise and Daphne all spoke to the extra time and effort that is required of teachers, especially when accepting different types of products from students and making sure that they are all equivalent in terms of effort and depth. In Peter’s words “It’s exhausting trying to come with different ways to say the same thing”, which is another challenge faced by teachers who teach science to ELLs. Daphne explained,

For example, if one person is writing a 10 page report on something, is that the same thing as somebody else doing a modern dance interpretation of it?

So it’s about being able to find the right kinds of products that they can do that will still challenge them.
This corresponds to the research carried out by Vang (2006) on the importance of teachers allowing students to develop their own modes of knowledge-representation. However, my interpretation of the data is to examine it under the lens of a challenge that teachers of ELLs may face in designing such products and their assessments rubrics.

4.3 Successful Methods Participants Have Used to Help ELLs

Once again, the three participants offered a wealth of information and examples of teaching strategies and instructional approaches that they have incorporated into their science classroom to help appropriately integrate and engage English Language Learners and minimize the achievement gap between them and their fluent English speaking peers. According to the literature and research by Lee and Buxton (2010) and Garza et al. (2014), there are instructional strategies that are pivotal for science learning and the ones implemented by my interview participants are discussed in the subthemes below. The following subthemes aim to respond to three of the subsidiary research questions: 1) What strategies (e.g. Differentiated Instruction) do teachers use to facilitate the conceptual learning of ELL students in science class? 2) How do teachers confront the challenges that they experience in responding to the needs of their ELLs? And 3) What factors and resources support teachers in overcoming these challenges?

4.3.1 Teacher Efforts to Create a Safe and Welcoming Environment for ELLs

Before plunging into the strategies that the interview participants used to help ELLs in science specifically, I look at their general approaches used to integrate and assist ELLs in their classrooms.
To begin with, I report on how the interview participants strive to integrate the ELLs into their classes, making sure that they feel welcomed, comfortable and confident enough to participate and ask their questions. According to Peter, who touched on the idea of integration frequently during our interview, he “integrate(s) them in every way possible”, “make(s) them feel that they are always welcome” and only begins to call on them after they have been in his class for a few weeks, gotten used to the class routines and Peter’s speech patterns. Only then will he begin to call on them and ask simple questions; Peter clarified,

I just want them to feel acclimated as part of the room, as part of the group.
I make them feel that they are always welcome and then eventually after a couple of weeks have gone by I start slowly asking some questions, not really hard ones to begin with, but just to make them feel part of the class and to make them feel like they’re participating and sharing what they do.

He continued to say:

The questions I ask them at the beginning will be fairly simple ones that don’t require a lot of verbose response, “What happens when you drop a ball?” “Well, it falls” I don’t ask for “The acceleration of gravity and more complex terminologies”

He also provides them with extra help before or after school, and makes sure that he is always available for his ELLs to ask for help when they need it. However, Peter, Daphne and Louise clearly articulated that they do provide extra, individual support for the ELLs that doesn’t take place right in the middle of a lesson, where they might risk losing the interest of the rest of the students in the class and jeopardize the flow of the lesson. Peter explained,
I tend not to stop in the middle of the lesson to deal with one or two issues. Like that just because I will definitely lose the rest, I will lose the thread of the lesson, I will lose the thread of what ties the rest of the group to the lesson. So I refuse to let that happen.

This points to the importance of keeping the flow of the class and lesson and dedicating extra time to provide the support that the ELLs might require, without disrupting the rest of the class. However, these supports do not only have to be individualistic and outside class times, they can also be provided during times when the whole class is engaged in an activity or task. According to Daphne,

> It’s not like I’m stopping the class in order to focus on an ELL and everybody else is doing nothing. This is in the context of actually doing the work, so everybody is busy..., it makes it easier to go around and it also makes it easier for me to approach my ELLs without kind of highlighting them or pointing them out in the class.

It is important to note that this benefits the ELLs along with the whole class, as the ELLs are not singled out by the teacher’s extra attention, and the rest of the class is able to stay on task.

Also, the participants discussed the importance of making sure the classroom environment is one that is open, inviting and relaxed, and how they avoid singling out the ELL students in the class and try their best to make sure these students “realize that they’re part of the class.” Peter mentioned how adding humor also maintains a light atmosphere in the classroom. Louise spoke about the importance of being involved in extracurricular activities where “students feel comfortable with you” and how this provides another opportunity to
engage with them in conversations, giving the students the sense of being valued and also allowing them to practice their English language skills.

In concert with the research carried out by Amaral et al. (2002), the participants also touched on how they use cooperative learning strategies of pairing or grouping ELL students with classmates, mixing the groups around, either having ELLs together in a group or integrating them into a group of fluent English speakers. The participants spoke to the benefits of both grouping strategies, in terms of benefits for all students in the group, making sure everyone “benefits from the learning” to quote Louise. Daphne said, on grouping the ELLs together,

> When you have that peer tutoring going on with the stronger ELL being able to guide the weaker ELL, it is actually really effective. I [also] can provide the particular pod of ELLs with some additional supports, additional explanations, while they’re doing the work because they’re all together, so I can help them out a little bit more, or model it a little more, so they’re doing the same activity as everybody else, but maybe they get some additional explanation or diagrams or graphics to help them with it.

Furthermore, participants discussed having fluent English speaking students, born and raised in Canada, who may come from the same background as the ELLs, placed in the same group. This means these students can provide additional support for the ELLs, allowing them to feel a sense of comfort knowing that if they “absolutely, positively cannot express themselves, at least the other person can still understand them in their first language”, which is in line with the research done by Buxton et al. (2008) and Allen and Park (2011) where they
converse on the effectiveness of using peer support to assist English Language Learners’ science learning.

4.3.2 Strategies to Teach Science to ELLs

The interview participants provided valuable insights into the strategies they use to teach science to the ELLs in their classes.

When the topic of differentiated instruction as an instructional approach used to facilitate the conceptual learning of ELL students in science class was discussed with the interview participants, it was evident that they shared a similar understanding of what differentiated instruction entailed. They believed that differentiated instruction’s main aim is to use the teachers’ understanding of where students are and where they need to go in terms of their learning, allowing them to gain and show their understanding in the best way that they are able to, through the different avenues of learning. Peter, Daphne and Louise all agreed that effective differentiated instruction was valuable for all the students in the class and even more so for the ELLs. Louise described its importance in terms of allowing the ELLs the opportunities to learn despite their limited language proficiencies and Daphne deliberated on how it allows ELLs to express their understandings in ways that are not necessarily the same as their fluent English peers’.

Furthermore, Peter shared how he accommodates for the ELLs in his class by “reducing the number of tasks that I have them [ELLs] do” and “have them [ELLs] sitting fairly close to me in class.” He continued to explain how this allows him to respond swiftly to any questions they may have, without them feeling exposed to the rest of the class, and without losing the flow of the lesson. He also discussed how he tends to shorten their tests, and let them write their tests in a separate/ESL-dedicated room. These strategies are meant to
reduce the amount of anxiety that the ELLs may be feeling in class and during test-taking times. I believe that by doing this, Peter is trying to maintain the motivation and self-esteem of his ELLs, which is consistent with recommendations made by Krashen (1982) who describes how anxiety-inducing language shock tends to negatively impact a student’s motivation and self-esteem. Both Daphne and Louise described providing ELLs with extra time to reduce student anxiety levels. As Daphne put it, this provided “additional processing translational opportunity.” This is consistent with Vang’s (2006) findings on the importance of allowing students “extra time to assimilate information, complete their thought processes and decipher scientific implications” (p. 37).

Louise and Daphne also discussed how they addressed teaching science to ELLs by recounting situations where they had ELLs in the past whose English fluency was very limited, but whose “…chemistry was really sound” (Louise). In these situations, Louise described how she was constantly aware of this during the designing of her tests:

I always had to be very mindful that on my tests that I used items that are universal, for example, balancing a chemical equation is universal, it doesn’t matter what country you come from. So, I would make sure that my instruction is limited in terms of not having a whole paragraph to explain something as opposed to having it in a sentence.

In this manner, Louise addressed the importance of using universal signs and symbols, not only during instruction but also during assessments, to ensure that the language deficit does not constitute a serious barrier to the students’ learning of the content.

Daphne described how her main focus for ELLs is building their general vocabulary, and articulated how she may facilitate the language component in her tests by providing a
description in brackets next to a word that is not a science-specific one, or by including a picture. She explained that “…for someone who already understands the language, it’s just a picture, but for ELLs it’s something that provides context for the words, and that can help them out.” I found that this aligns significantly with the literature by Amaral et al. (2002) on the importance of science education and how it provides a context in which ELLs can continue to develop their literacy skills.

Peter and Daphne both elaborated quite extensively on how they tackle the vocabulary challenge that ELLs face in science by using a variety of different strategies to facilitate the learning of science-specific terminology. Interestingly, both participants stressed that because these strategies are beneficial for the entire class, they are especially beneficial for the ELLs. Peter explained how he encourages and helps the students “break down” new or heavy vocabulary by talking about what a word is, what it means and providing them with the scientific definition. Immediately after, he follows up with “OK, now let’s put this into a dialogue that we can use to explain it to an 8-year old”. Daphne described her similar strategy even further:

When I go through vocabulary, new words, one thing I do is break them down, telling them what prefixes and suffixes mean, what particular roots mean, so that they can start to build up that science vocabulary.

I see the benefit of such an approach of simplifying scientific vocabulary which can be intimidating even for the fluent English speakers in the class. This ties in well with what Louise referred to as “good pedagogy”. She explained that good practices of teaching are of value—and helpful—to all students in the classroom, and even more so for students who are learning English.
Daphne continued to specify how she provides her ELLs with an option to pre-screen their written work for the purposes of checking grammar, spelling and vocabulary, as she avoids judging the actual scientific content or conclusions made. When she taught an ESL science class, Daphne allowed the English Language Learners the opportunity to create their own “science dictionaries” into which students inputted new words they came across, added definitions (either in their own words or in their native language) and drew or pasted pictures. These science dictionaries were then used as reference books whenever the students had a test; it “allows them [ELLs] to use the knowledge that they already have and be able to apply it to the English science class.” This also points to the importance and effectiveness of allowing student choice and voice, as the students take pride in creating their own personalized science dictionaries that are designed, ultimately, to facilitate their learning of English simultaneously with their learning of science disciplinary knowledge. Furthermore, Daphne elaborated on times when she allowed her ELLs to complete a scaffolded laboratory report, one in which most of the language is already present, but there may be blanks for specific scientific terms. She said,

Let’s say we are doing a lab on Density, I may leave blanks for things like Mass or Volume or Density, so very specific vocabulary words, as opposed to having them write out a full lab report…this way we’re still able to assess them on the knowledge without being hindered by their lack of language.

In these aspects, I believe that Daphne’s strategies show that she implements the effective instructional strategies used to support ELLs’ science learning, according to Allen and Park (2011) and is also in line with the research by Buxton et al. (2008) on reducing difficult language to key vocabulary and using simplified sentence structures.
4.3.3 Human and Material Resources Used to Support ELLs

Using this subtheme, I aim to answer the subsidiary research question of what resources teachers use to support the ELLs in their classrooms. The supports discussed below fall under the categories of “human” resources (which includes fellow classmates as well as other support systems found in schools) and other assistive resources, such as textbooks, that the participants have found useful.

To begin with, I discuss the “human” resources that my interview participants have found useful in responding to and meeting the ELL students’ needs. Firstly, the participants spoke to the effectiveness of allowing fellow classmates to assist in the integration and, ultimately, the learning experience of ELLs. For example, in concert with the research by Allen and Park (2011), both Daphne and Peter discussed how they sometimes allow the ELLs to choose their own lab partners and this allows them to pick the students they are the most comfortable working with. Louise and Daphne also elaborated on the role of the English as a Second Language Department and ESL teacher in the school and how important it is to collaborate together for the benefit of the ELL student. Also, they mentioned the school Guidance team, which is of particular benefit when ELLs are on an Individual Education Plan (IEP). Louise explained how in these ways, because the ELLs are officially identified in the system, they are allowed further supports such as extra times on their exams and the use of a dictionary. She also stressed the benefits of having Instructional Leaders who support the teachers of ELLs and provide them with opportunities to engage in conversations in terms of what the best practices for the ELL students would be.

Secondly, the interview participants talked about other, non-human, resources they use to support their ELLs in science. When the topic of science books were discussed, their
effectiveness, according to each participant, varied. Peter, for example, found the material presented in textbooks “rudimentary” and unstimulating for the learners, and therefore he resorted frequently to the internet as a resource to support his ELLs. On the other hand, Louise, discussed the benefits of having informational texts, such as foldables, to engage students in the context of science as well as the development in the quality of teacher resource binders available now (where many textbooks now have specific sections for the ELL students). Daphne adds visuals and online resources that she uses frequently to support her ELLs. She explained “I’ll have a PowerPoint running through the lesson with animations and videos that are usually imbedded somewhere in the lesson”.

These supports used by the interview participants are all comparably analogous with the various research carried out by Garza et al. (2014), Allen and Park (2011), Lee and Buxton (2010) and Amaral et al. (2002) on how to effectively support English Language Learners.

4.4 A Tension between Equality versus Equity in Assessment and Outcomes of ELLs

Before proceeding, it is important to note that although the equality and equity approaches are both used to promote fairness, there is a significant difference that must be addressed. Equality is treating everybody (all the students in the class) in the same manner, while equity is providing everybody with the means that they need to be successful. It encompasses a wide variety of educational models, programs, and strategies that may be considered fair, but not necessarily equal (Hidden curriculum, 2014).

The three following subthemes aim to answer three of the subsidiary research questions: 1) How do teachers assess the learning needs of the ELLs? 2) What outcomes do teachers observe from their ELLs in terms of their disciplinary knowledge of science? And
3) How do they evaluate the learning outcomes of their ELLs in the context of the
expectations set forth in the science curriculum?

4.4.1 Assessing Learning Needs

The three interview participants were very aware of the difference between providing
equal versus equitable learning opportunities for the ELLs in their classes. In terms of
assessing the learning needs of their ELL students, the three participants all relied on the
equality approach of getting to know their students - all of their students, not only the ELLs.
Louise articulates this clearly when she explained how every student in her class was
required to complete a Multiple Intelligence survey at the beginning of the year:

You need to know who your students are and that is an important precursor
for us to understand who our leaners are before we actually even start
creating lessons for individuals.

This is in line with Garza et al. (2014), who discussed how the effectiveness of a strategy is
dependent on the students’ learning needs and preferences. By getting to know their students
well, teachers are better able to relate science to their students’ background experiences, as
has been called for in the literature (Lee & Fradd 1998; Fraser-Abder, 2001).

4.4.2 How the Learning is Evaluated

In this subtheme, I address how my interview participants have evaluated the learning
outcomes of their ELLs in the context of the expectations set forth in the science curriculum.
I report on their assessment and evaluative practices. Louise spoke about the importance of
chunking materials well enough in order to provide ELLs with the opportunities to practice
their learning through assessment for and as learning, so that the final evaluative piece is
reflective of good learning. In the same sense, Daphne discussed how the expectations for the ELLs are not modified and maintained the importance of evaluating the ELLs in the same manner as their fluent English speaking peers in order to preserve the integrity of the credit of the course. This suggests that these two participants assess and evaluate their ELLs in the same, equal, manner that they assess and evaluate all their students. Peter’s approach, on the other hand, suggests that he uses a more equitable assessment strategy. He described how he is more “lenient with ELLs in terms of the content” they provide him with, explaining that because of their language limitations, he tends to be more flexible when assessing the work of ELLs than he is when assessing the work of fluent English speakers. This raises the concern of how we approach assessment for ELLs: Does an equitable approach call for different approaches to assessment? How do we avoid lowering expectations of ELLs while still taking into account the challenges they face?

4.4.3 The Observed Outcomes

When asked about what outcomes they generally observed from their ELL students, in terms of their disciplinary knowledge of science, all three interview participants talked about positive outcomes from the ELLs. This suggests that they truly do believe in the effectiveness of the strategies they are using to help benefit their ELLs. Peter, however, also touched on a concerning outcome he observed. He described how English Language Learners tend to “glom” onto the basic scientific facts and have difficulties maneuvering abstract thinking and the application of abstract concepts. He states “That’s what I find with a lot of ELLs kids that they glom on to the concrete stuff first because it’s the easiest to get.” It is his belief that ELLs do this because it is easier to understand and remember concrete facts, but noted that as their confidence with the English language grows, so does their ability
to grasp abstract concepts. This falls in line with Vang’s (2006) research on allowing ELLs extra time to assimilate scientific information and decipher scientific implications.

4.5 Conclusion

This chapter has reported on the different findings from the interviews carried out with three science teachers on their experiences with ELLs in their classes. My analysis of the data collected from the interviews provided insight in response to the questions that guided my research. These were discussed in light of current research relating them, where possible, to the literature review. Analysis explored: 1) the perceived reasons behind the presence of an achievement gap between ELLs and their fluent English speaking peers; 2) the various challenges faced when teaching and learning science; 3) the successful methods research participants have employed to support ELLs; and 4) the importance of an equity approach to supporting and assessing learning outcomes for ELLs.

In the final chapter, the significance of the findings discussed here will be further elaborated upon. Additionally, I will make recommendations stemming from the study’s research findings and suggest areas for further research.
CHAPTER 5 - IMPLICATIONS

5.0 Introduction

The present research study was designed to learn more about how mainstream classroom science teachers facilitate the learning of the English language along with the disciplinary knowledge in science for the English Language Learners (ELLs) in their classrooms. It intended to ascertain the different pedagogies, methodologies and instructional approaches used by science educators and teachers to successfully bridge the growing educational achievement gap observed in science education between non-native English speakers and their native, fluent English speaking peers.

This qualitative research study used semi-structured interviews to explore the reasons behind an achievement gap between English Language Learners and their proficient English speaking peers. This study was also explored how science teachers meet and overcome the challenges of teaching science to ELLs. The semi-structured interviews were conducted face to face with three participant teachers who met the prerequisite criteria of being exemplary teachers, with a minimum of five years of teaching science experience and who teach, or have recently taught, science to a diversely-linguistic class at the intermediate level.

Findings from the analysis of the interviews and the patterns I identified through the analysis are consistent with the extant literature examined and discussed in the literature review. This study contributes to our knowledge of how we might best support teaching science to ELLs in mainstream classrooms by exploring the following themes: 1) The participants’ perceived reasons for the achievement gap, 2) The challenges that are involved both in the teaching and learning of science for ELLs, 3) The successful methods the research participants have used to support and cater to the specific needs of ELL students in their
classes as well as 4) A tension between equality versus equity in assessment and outcomes of ELLs.

This chapter summarizes the research findings, highlights the present study’s implications for various stakeholders, provides several recommendations, and suggests directions for future research.

5.1 Overview of Key Findings and their Significance

Following the interviews with three educators, a rigorous analysis revealed four important themes: 4.1) Participants’ acknowledgement of the presence of an achievement gap, 4.2) Teaching and learning challenges of science for English Language Learners, 4.3) Successful methods used to help English Language Learners, and 4.4) A tension between equality versus equity in assessment and outcomes of ELLs.

The first theme, 4.1, served to remind us that there is indeed an educational gap being experienced by non-fluent English speakers in comparison with their fluent English speaking peers which is recognized by the practicing research participants. This gap can be attributed to several reasons and factors that we as teachers and educators need to be cognizant of in order to successfully integrate our ELLs into not only our science classes, but into our general classes as well.

The second theme, 4.2, aided in reminding us that there are varying challenges when it comes to working with ELLs. There were two main types of challenges that were highlighted by the participants and which represent key findings within this theme. First, were challenges ELLs faced in learning science as a subject matter; namely the arduous subject-specific vocabulary that tends to be of European origin which many ELLs are unfamiliar with, and the
alienating culturally-specific textbooks that are relied on heavily in science class. Second, teachers who teach science to ELLs faced various challenges such as designing the right kinds of products that are challenging to the ELLs yet attainable, and the time spent and effort exerted by the teachers in creating effective assessment rubrics to assess such products.

The third theme, 4.3, revealed valuable information on how the participants integrated ELLs into their classrooms. The participants highlighted the following facets: 1) the importance of the classroom environment, 2) the initial probing/questioning techniques they used to formatively assess their ELL students’ levels of knowledge and understanding, 3) the extra help opportunities provided to support their students, 4) the importance and effectiveness of using cooperative learning and grouping strategies, each of which has its own benefits and setbacks, so must be planned into a lesson very carefully, 5) the techniques used by the participants to overcome the struggle that is scientific vocabulary and finally, 6) the different supports utilized, both in class and throughout the school, to assist ELLs.

The final theme, 4.4, cast light on the two approaches of equity and equality used by the research participants to promote fairness and assess and evaluate the learning outcomes of the ELL students in their classrooms. Although equity and equality are different approaches, the research participants were aware of the differences and ensured that equality was enforced and in place at all times in their classrooms, for all their students, in addition to ensuring that all their students were assessed in an equitable fashion, with the degrees varying between the participants.
5.2 Implications

In this section I address the broad and narrow implications of the study’s findings. The findings’ broad implications for the educational community, including policymakers and curriculum planners, school boards, schools and pre-service teacher education programs, are considered. The findings’ narrow implications for teachers who work with ELLs in science education, including myself as a teacher, are also addressed.

5.2.1 Broad Implications

This study has important implications for educational reform. In broad strokes, this study serves as reminder not only to policymakers and curriculum planners, but also to school boards and teachers that a lot more needs to be done in order to ensure that English Language Learners are receiving the science education and support that is warranted of the Canadian educational system. Schools need to consider the environment the ELLs are being accepted into, in terms of the whole school environment, and the allocation of necessary accommodations to be made for ELLs (such as the allocation of extra time for information assimilation). Pre-service teacher education programs need to begin implementing courses that address working with, and assessing, linguistically-diverse learners for teachers to be properly prepared to work with ELL students and effectively meet their diverse learning needs. This is consistent with the research that repeatedly points to the lack of both adequate teacher knowledge and institutional support in addressing the educational needs of ELLs, and especially in the effectiveness of teachers in teaching science (Lee & Santau, 2008; Lee, 2005; Kennedy, 1998; Loucks-Horsley et al., 2009).
5.2.2 Narrow Implications

This study highlights the critical role of teachers in supporting English Language Learners in science education. Teachers working with ELLs should consider the high levels of student anxiety that can interfere with learning. They must also be cognizant of language shock and the frustrations it creates for individuals whose communication is compromised. In accordance with the research done by Krashen (1982) and Miller and Endo (2004), the anxiousness created by language shock, a phenomenon that language learners experience when adjusting to their new environment and especially when trying to learn a new language (let alone learning science in a new language), results in a drop in a student’s motivation and self-esteem. Not addressing ELLs’ anxieties and language shock can have devastating effects on students’ achievements in the long and short term. The responsibility to properly, and instantaneously, mitigate these concerns falls on the shoulders of teachers and must be taken very seriously.

When considering these implications for myself as a teacher, I feel fortunate to have selected this topic for my MTRP research, because I feel that when I do find myself with ELL students in my class, as this is only a matter of time given the diversity of the city of Toronto, I would be more prepared to cater to their varying learning needs. The findings of this research have exposed me to the various challenges that English Language Learners face in their science education. Because of this research study, I am more aware of the situation and find myself armed with a wealth of knowledge and strategies that can be used to support ELLs in both my science classes and other subject areas as well.
5.3 Recommendations

The implications of this research study point specifically to several recommendations for ministries of education, school boards, teacher education programs and teachers.

Four recommendations are outlined below:

1. Ministries of education should consider beginning to not only acknowledge that there are vast numbers of ELLs entering the school system every year, but also begin to plan effectively for their successful inclusion and integration into the system. Policies and firmer rules and regulations must be put into place and implemented to ensure that ELLs, regardless of their cultural or linguistic background and abilities, have adequate and equitable access to the support they require to achieve academic success. For science education, more specifically, ministries of education can make available more resources, such as science textbooks that include more culturally specific and relevant examples, and other learning materials, like the foldables Louise described using, which accommodate for ELLs and are designed to support their linguistic as well as scientific progress.

2. School boards need to reconsider reducing the number of students in each class, and the overall sizes of schools they are responsible for. This recommendation in itself is one that would benefit the overall population of students in Ontario, not only English Language Learners. All learner would benefit from smaller class sizes, where instruction would be more individualized and designed to cater to the students’ different learning styles. The school boards must also work on providing more education programs that meet the needs of ELLs’ communities, such as providing and promoting English Language Centers. These centers would aim to provide English language lessons and ensure that members of the community would receive adequate English language support to facilitate their
integration into the community and its schools. It is the role of the school boards to effectively monitor teacher performance more rigorously while helping teachers improve their teaching practices by providing more workshops and training opportunities to support and help science teachers meet the needs of their ELL students. The boards should also reexamine the supervision of school operations and teaching programs, enforcing stricter measures that ensure ELL students are receiving the linguistic support from teachers and school Guidance teams that would truly work to the benefit of the students. Finally, the boards should also focus more on the nature of the resources provided to support ELLs, such as allowing the use of dictionaries and the use of quality Teacher resource binders to be used by teachers.

3. It is my recommendation that teacher education programs dedicate more time and energy to prepare pre-service teachers to provide equitable science education to ELLs. In my opinion that teacher education programs also must undergo a complete transformation. From my experience at the teacher education program at OISE, I feel somewhat unequipped to deal with the challenging feat of supporting ELLs in science education. Although I must acknowledge the fact that the issue was addressed in a few of my science education courses. I am particularly concerned for teachers who do not have science as a teachable and who did not engage in this research on supporting ELLs, but who might be called upon to teach science to classes that include ELLs.

4. Teachers have a great responsibility on their shoulders to deliver an adequate level of education for all their students. It is the duty of ministries, teacher education programs, school boards and schools to provide sufficient support for teachers, in all manners possible. The responsibility of equipping the children and youth of this democratic society
with the knowledge and skills that will assist them in becoming responsible, contributing
members of society rests firmly on the shoulders of their teachers and educators. The
responsibility is indeed a great one; one that can only be achieved by motivated,
passionate, and driven teachers who are life-long learners themselves. This responsibility
requires teachers to be cognizant of the importance of continual teacher development and
seek out various opportunities to cultivate their abilities and skills to deliver a strong
educational foundation to all of their students.

5.4 Areas for Further Research

Inasmuch as the present research study has served to expand upon the extant literature on the
topic of teaching science to English Language Learners, it has also highlighted the need for further
study. It is recommended that future research place a greater emphasis on what the ministries of
education in the different provinces are doing to address the gap in science education between
ELLs and fluent English speaking students. Also, the incidence and usefulness of ongoing
professional development workshops provided by ministries and school boards should be studied
to gain a better understanding of how effective such workshops are and to help ensure that the
required services are indeed being provided and that the teachers who attend them do actually
benefit from them. In addition to this, educational research scholars need to direct their attention to
the effectiveness of pre-service teacher training programs in order to ascertain how effectively
graduating teachers are being equipped with the tools and skills that they will need to use once
placed in a classroom teaching science to linguistically diverse students.
5.5 Concluding Comments

The present research study is important because it casts light on and explores the plethora of challenges faced by teachers when teaching science to English Language Learners in a setting where they are also required to teach science to fluent English speaking students. The achievement gap between the two groups must not be ignored or overlooked.

In order to ensure that each and every student, regardless of race, ethnicity or linguistic ability, is afforded an equitable opportunity in science education, efforts to eliminate discrepancies in science education to Canadian students require changes at many educational levels (ministries, school boards, teacher training programs and teachers themselves). Further research at each level is needed to address and eliminate the educational gap in science between ELLs and their fluent English-speaking peers.

The necessity of bridging this achievement gap cannot be overstated. Although it is not a task that can be accomplished overnight, it is imperative that rectifying measures be put into action to ensure that all students in the Canadian education system receive the education that they deserve. Although these measures may begin at the highest levels of the ministries of education, they ultimately benefit those who need them the most: the students.
REFERENCES


Galletta, A. (2013). *Mastering the semi-structured interview and beyond: From research design to analysis and publication*. NYU Press.


APPENDICES

Appendix A: Letter of Consent for Interviews

Date: ________________________________

Dear ________________________________.

My Name is Reem Karam Attia and I am a student in the Master of Teaching program at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). A component of this degree program involves conducting a small-scale qualitative research study. My research will focus on how mainstream intermediate science teachers’ work bridge the gap between English Language Learners (ELLs) and native English speaking students in the science classroom. I am interested in interviewing teachers who have experience with working with both ELLs and fluent English speakers in Science class. I think that your knowledge and experience will provide insights into this topic.

Your participation in this research will involve one 45-60 minute interview, which will be transcribed and audio-recorded. I would be grateful if you would allow me to interview you at a place and time convenient for you, outside of school time. The contents of this interview will be used for my research project, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a research conference or publication. You will be assigned a pseudonym to maintain your anonymity and I will not use your name or any other content that might identify you in my written work, oral presentations, or publications. This information will remain confidential. This data will be stored on my password-protected computer and the only people who will have access to the research data will be my course instructor Dr. Rodney Handelsman. You are free to change your mind about your participation at any time, and to withdraw even after you have consented to participate. You may also choose to decline to answer any specific question. I will destroy the audio recording after the paper has been presented and/or published, which may take up to a maximum of five years after the data has been collected. There are no known risks or benefits to participation, and I will share with you a copy of the transcript to ensure accuracy.

Please sign this consent form, if you agree to be interviewed. The second copy is for your records. I am very grateful for your participation.

Sincerely,
Reem Karam Attia
reem.karamattia@mail.utoronto.ca

Course Instructor’s Name: Dr. Rodney Handelsman
Contact Info: rodney.handelsman@utoronto.ca
Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw from this research study at any time without penalty. I have read the letter provided to me by Reem Karam Attia and agree to participate in an interview for the purposes described. I agree to have the interview audio-recorded.

Signature: ________________________________________

Name: (printed) ________________________________________

Date: ________________________________________
Appendix B: Interview Protocol

Interview Questions

Thank you for participating in this interview - your contributions to this research project are highly appreciated. The aim of my research is to learn about the reasons behind the existence of the educational gap between ELLs and fluent English speaking students in Science education. I also aim to explore how teachers such as yourself work to bridge this gap along with the differentiated instruction approaches and pedagogies used to overcome the challenges faced by ELLs in the Science classroom. The interview should take approximately 45 minutes and I will ask you a series of questions about your experiences and strategies used to support ELLs in your Science class. I would like to remind you that you have the liberty to refrain from answering any question that you may be uncomfortable with. Do you have any questions before we begin?

Section 1: Background Information

1. What is your name?
2. What grades and subjects are you teaching this year?
3. What grades and subjects have you taught previously?
4. How long have you been teaching Junior/Intermediate Science?
5. So I can get a better picture of your students, can you describe how linguistically diverse they are? (Approximately what percentage of them speak more than 1 language? Which languages are represented?)
6. How many ELL students do you have in your class this year? (How many, on average, do you have in your class each year?)
7. Typically, what does the achievement gap look like between your native English speaking students and your ELLs in your Science class?

Section 2: Teacher Practices (What/How?)

8. How do you identify an ELL in your class? (Are there any special diagnostic tests/procedures that you carry out? If so, can you tell me about them?)
9. Tell me about how you proceed to integrate ELLs into your classroom, in general?
10. How do you respond to the needs of your ELLs through differentiated instructional approaches? (Can you give specific examples of differentiated instructional approaches
that you use in the Science classroom?) What does differentiated instruction for ELLs look like in your Science classroom?

11. What are your learning goals for ELLs in intermediate Science?

12. What do you do to minimize the achievement gap between you native-English speaking students and your ELLs?

13. Are there instructional strategies or approaches that you take to differentiate your instruction for ELLs to combine support for English language learning while learning scientific subject-matter? (If so, could you tell me about them? Why do you think they have been effective?)

14. How do you evaluate the learning outcomes of your ELLs in the context of the expectations outlined in the Science curriculum?

15. Generally, what outcomes do you observe from your ELLs in terms of their disciplinary knowledge in Science class?

16. Do you ever find the rest of the fluent-English speaking students in your class losing interest/becoming bored if/when extra time is allocated to the ELLs? (If so, how do you overcome this obstacle?)

17. What resources do you use to support and facilitate Science learning for ELLs while maintaining the interest and engagement of the whole class?

18. Do you create any opportunities for ELLs to work collaboratively with native English speakers in the Science classroom? Why/why not?

Section 3: Beliefs/Values (Why?)

19. What does differentiated instruction mean to you?

20. In your view, what are the benefits and challenges that come from differentiating instruction?

21. What range of factors do you believe contribute to creating an achievement gap in Science outcomes between your native English speaking students and your ELLs?

22. What are some of the most common challenges that your ELLs face in Science learning? How do you respond to those challenges? How do you think the education system could further contribute to responding to those challenges?

23. Why is it important to you to differentiate your Science instruction for ELLs?
Section 4: Influencing Factors (Who?)

24. What challenges, if any, do you encounter in this work? How do you respond to these challenges? What would further support you in meeting these challenges?

25. What sort of feedback have you received from outside the classroom about the methods you use to integrate ELLs into your Science classes?

Section 5: Next Steps (What Next?)

26. What advice would you give to a novice Science teacher looking to effectively integrate ELLs into their Science classes?

Thank you for your time and participation.