IN SEARCH OF INTELLECTUAL EMANCIPATION: READING *AS* INQUIRY IN AN ELEMENTARY SCIENCE CLASSROOM

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ABSTRACT

IN SEARCH OF INTELLECTUAL EMANCIPATION: READING *AS* INQUIRY IN AN ELEMENTARY SCIENCE CLASSROOM

This dissertation reconceptualizes traditional science education pedagogy and proposes an emancipatory model for students learning science. The foundation for the model is an interpretation of intellectual emancipation as theorized and articulated by Jacque Rancière (1991) in the *Ignorant Schoolmaster*. The study focuses on reading *as* inquiry in school science and the use of a student's first language as a learning resource. The investigation seeks to observe the teacher and students' journey towards intellectual emancipation as students learn science and discover or gain knowledge of their intellectual abilities.

Specifically, my research study presupposes that school science can be a stultifying environment where the teacher heavily controls knowledge. Within this context, learning through inquiry is too often conducted with an emphasis on 'hands-on' activities. This overemphasis leaves little room for the development of inquiry through reading and therefore, implicitly de-emphasizes the importance of reading for the development of independent, autonomous thinkers for a scientifically literate populace.

The experiment is set within the context of teaching science to English language learners. From a stance of "teacher/researcher" (Cochran-Smith & Lytle, 1993), I conduct an action research study with multilingual and multiethnic grade six students within an urban elementary classroom setting. I changed my classroom practices to foster greater 'intellectual emancipation' through the use of reading as a form of science inquiry.

Student behaviors or themes emerged from the data that I associated with expressions of intellectual emancipation. The results of the study and the interpretation of the results add to the discourse of emancipation, inquiry, and learning science. Inquiry is widely advocated in practice, research and policy. A study such as this supports classroom teachers to challenge the dominant approach to inquiry in school science as 'hands-on' and to seize the emancipatory opportunities that inquiry as 'minds-on' offers for the development of the whole learner.

DEDICATION

This dissertation is dedicated to my family who stood by me through the peaks and valleys of my educational journey and to God' grace for sustaining me with the strength to achieve this goal while keeping my love of learning and a passion for my career in education intact.

To my parents, Arnold and Dr. Ertrice Eddy who always valued education and encouraged me in reaching this personal goal.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

This dissertation describes an experiment in pedagogy teaching science to English language learners. From a stance of a "teacher-researcher" (Cochran-Smith & Lytle, 1993), I conduct an action research study with multilingual and multiethnic grade six students within an urban elementary classroom setting. This forms a case study (Stake, 2005; Yin, 2009) in which I investigate changing my pedagogical practices to foster greater 'intellectual emancipation' through the use of reading as a form of science inquiry. In this introductory chapter, I begin with reflections on my practice and describe the motivations for this case study. This discussion outlines the research problematic. Next, I provide an overview of the study that highlights the research questions. I conclude with a brief description of each chapter to follow.

1.2 Reflections from My Practice

The idea of reflection in professional practice has a long and established tradition. For example, Dewey as early as 1903 discusses reflective thinking. Dewey writes about the critical connection between experiences and reflections in processes of learning to teach. More recently, Schon (1983) extends Dewey's work by drawing distinctions between different contexts of reflection; reflections *in* action and reflections *on* action (Schon, 1983), and Carr and Kemmis (1986) introduce and establish the concept of 'critical reflection' in relation to teacher thinking and action research.

Over the years, I have sought to improve my teaching practice through critical reflections both *in* and *on* practice. My primary goal is to deepen the learning experiences of my students. My professional experiences with colleagues and students set me on a path of reflective exploration. This is the starting point for the following dissertation, which might best be described as a journey of reflexive inquiry. As a science graduate involved in elementary education for the past ten years, my academic background and passion for science prompts curiosity about the kinds of learning experiences students obtain in science classrooms. In what follows, I highlight some aspects of my practice with attention to particular 'critical incidents'. That is the specific events that provoked and sustained my professional reflection. Here, I use the term 'critical incident' drawing from the perspectives of Tripp (1993), and Nott and Wellington (1998). Tripp defines a 'critical incident' as an incident that has a significant impact on one's personal and professional learning by challenging thinking or raising questions about beliefs, attitudes or behavior. Tripp (1993) draws attention to the criticality of the commonplace:

> The vast majority of critical incidents . . . are not at all dramatic or obvious: they are mostly straight forward accounts of very commonplace events that occur in routine professional practice which are critical in the rather different sense that they are indicative of underlying trends, motives and structures. These incidents appear to be 'typical' rather than 'critical' at first sight, but are rendered critical through analysis. (pp. 24-25)

Nott and Wellington (1998) reflect their science educator perspective in describing a 'critical incident' as that which stimulates a reaction from the teacher and provides insight into the views of science and aspects of teaching and learning.

Two particular 'critical incidents' impelled my desire for research, the first being an *"I can't do it"* attitude exhibited by some of my students. This attitude emerged through my classroom-based observations of students' seeming lack of confidence in their abilities. The attitude is not necessarily associated with an unwillingness to learn or participate in class, but rather a preference to learn or participate when told explicitly what to do and with constant explaining. For example, students will often raise their hands and ask for help to understand instructions for an assignment, problem-solving activity/question, or almost any text that was not narrative in form. This help will usually result in me going to the student and explaining the text (sometimes repeatedly) to them individually or the class as a whole. I found myself trapped in a cycle of explaining my explanations as students failed to understand my previous attempts. In my practice, I interpret these exchanges as perpetuating a 'learned helplessness' on the part of the students I am helping and those who wait for me to attend to them. Over the years, in casual conversations with students many are forthcoming with their insights explaining that if they perceive the instructions, assignment, or text as having too many words or sentences, they will not bother to read it or at the most skim read it. Many students openly acknowledge, "*it's easier for the teacher to just explain it.*" Concomitant with this observation is my experience of the passivity of many students as learners. For example, to elicit students' opinions in a class discussion is difficult. Students are reluctant to express their own opinions and defend it to others. They are concerned with the 'right' answer and are adept in trying to gauge what they think the teacher wants to hear as the 'right' answer.

Upon closer reflection, I find myself implicated in both problems. With the first, I understand that the 'learned helplessness' was a cycle of which I was a part. However, at the time, I could not conceive a way to extricate myself. With students' reluctance to express ideas and opinions, I realize that my teacher-centered classroom most likely contributed to the issue. For example, my early years of teaching science consisted of lessons based on school resources such as the science textbooks and trade resources for English language learners. Lessons were teacher directed and comprised of various combinations of short bits of informational text, short answer questions, vocabulary building exercises, and hands-on activity. Recognizing the need to be less teacher-directed and more student-centered, I endeavored to place more emphasis on student-centered pedagogy. In this effort, I adopted a goal of using more Information Communication Technology (ICT) with desires of enhancing student learning and independence. Creating multimedia lesson formats that incorporated current information from online databases, educational websites, videos, pictures, and simulations, allowed my lessons to be more flexible with respect to class interests. In addition, students' own use of technology allowed more choice and flexibility to demonstrate understanding. Despite these changes, although more engaging, it was still nonetheless 'delivery' of content, and still more teacher directed than I desired. For the most part, an ordered, steady progression of content unfolded in the classroom. Alongside this endeavor, I attempted to be conscious of fostering a safe learning environment for intellectual risk taking by being more deliberate in providing practice, opportunities, and encouragement for students to express ideas and respectfully disagree with others while supporting their own ideas.

In more recent years, I further developed my understanding of teaching English language learners and recognized the importance of authentic integration of subject matter content and language acquisition. This juncture in time coincided with my school's focus on journal writing in mathematics. Specifically, the use of writing for critical thinking and understanding. The emphasis on writing for learning intrigued me. When I looked at my practice and the general standard of practice of elementary teachers in science, there was minimal student engagement with text or with students' own ideas in written form. This prompted my interest in research for my Masters degree that investigated writing for learning in elementary science.

As I was determining a focus for my doctoral work, I had an encounter with Rancière (1991), specifically his text *The Ignorant Schoolmaster.* This second 'critical incident' significantly impacted my personal and professional learning, thus prompting me to ask different questions and providing another lens through which to interpret professional experiences. The result is further insight and understanding of the students in my classroom practices.

1.3 Encounters with Rancière

Rancière's articulation of ideas that seemed to resonate with my classroom and systemic school experiences captivated me. His radical philosophy on teaching and learning unfolds through the story of Joseph Jacotot, a nineteenth century French teacher who taught students whose language he did not speak. Through his work with students, Jacotot discovered that knowledge is not necessary for teaching or explication necessary for learning. He found that transmitting knowledge through an ordered progression of simple to complex (explication) was not necessary for student learning. From these revelations, Jacotot conceives the principles of *universal teaching (*Rancière, 1991).

Rancière approaches intellectual emancipation through these insights. A major theme of his work is the idea of 'intellectual emancipation'. Through a series of arguments, Rancière challenges accepted educational practices by revealing that all people have the capacity to learn through their *own* intelligence, without the benefit of a teacher's explanations. He postulates that even though inequality may be a fact of social life, and that institutions such as school systems are based upon the assumption of inequality, if we (as teachers) assume equality of intelligence with students, we mobilize students' capacity to seize for themselves, their 'intellectual emancipation'. What immediately resonates is what Rancière identified as a barrier to intellectual emancipation. That is the idea of student stultification, which means the numbing or deadening of students' ability to exercise their *own* intelligence. According to Rancière, stultification of students is a result of believing in the inequality of intelligence between a teacher and students (Rancière, 1991).

The Ignorant Schoolmaster elicited both excitement and intellectual dissonance. On one hand, Rancière affirmed some of my experiences and observations in schooling and provided a new lexicon and schema in which I could think about the underlying issues more deeply and from a vantage point that I had not previously considered. On an emotional and spiritual level, it sparked within me excitement about possibilities for a different teaching and learning experience based primarily on changing one's thinking about intellectual positional relationships to others. On the other hand, the call to presuppose equality of intelligence created the dissonance between my emotional and spiritual response and intellectual willingness to accept his arguments versus the tension of being intellectually opposed to the arguments based on years of teacher education and participation in the systems and institutions of schooling, both as a student, and a professional.

Other points of interest in this work were the association between Jacotot's teaching context, that is, the connection between Jacotot, his students and language, and my teaching context with English language learners. In addition, emphasis on written text and reading in the progression towards 'intellectual emancipation' intrigued me.

My school-based observation of students and my encounter with Rancière were the critical incidents that were the catalyst for this study. It provoked me to challenge Rancière. Could his philosophy be enacted in *any* real world setting? Could it make a difference to the lives of learners in my classroom? What could it look like? Could I change my belief systems and practices enough to relate to my students as "equal" in a Jacototian sense? Could I be the "ignorant school master"? Could I get to an "emancipated place" where my learning experiences in my inquiry are derived from ignorance and enough to make a difference in my science practice? Moved to action, I conducted an experiment in intellectual emancipation. My response to these questions is the story outlined in the following chapters.

1.4 The Research Problematic

I propose that a scientifically literate populace in the 21st century should be, above all else, independent and autonomous critical thinkers. One way to foster these traits is to give students the freedom to think for themselves. However, in too many school science environments this opportunity is not frequently forthcoming. Instead, one finds environments where students can become 'stultified'. The stultification of learners, as I will argue, is not conducive to the development of a scientifically literate populace in which it is necessary to understand the role of science in our everyday lives, ask critical questions, and determine plans of action.

According to Norris and colleagues (Norris, Phillips, Smith, Guilbert, Stange, Baker, & Weber, 2008; Phillips & Norris, 2009) the ability to analyze, critique, and interpret text is required in order to use scientific information to make life choices, and engage intelligently in public discourse and debate about important issues that involve science and technology. However, much of the science reading in school is not critical reading or interpretation and is usually done in the context of language arts instruction (Norris et al., 2008; Phillips & Norris, 2009). For example, in elementary (grades 1 – 6) school environments across Canada, language arts instruction occupies the largest proportion of instructional time in contrast to the 10% for science instruction (Norris et al., 2008). Within this allotment, elementary school science is often perceived as 'hands-on' and reading in science is often used to understand isolated technical terms (Norris et al., 2008). Romance and Vitale (2011) note that a substantial body of research (Klentschy & Molina-De La Torrre, 2004; Norris & Phillips, 2003; Romance & Vitale, 2010; Webb, 2010) suggests that there are few opportunities for elementary students to engage in the form of content-area reading that enables them to border cross (Aikenhead, 1996) between everyday languages and the distinctive language of science. Further, Romance and Vitale (2011) cite researchers such as Chall (2003), Duke (2010), Guthrie et al. (2002), Pearson et al. (2010), and Snow (2002) as having advocated for the integration of "literacy" with science.

The focus on hands-on activity in school science has renewed calls from some researchers in the science education community to re-focus on the aspects of science literacy, such as reading. I believe this to be especially valuable for English language learners who learn science content and language simultaneously through content-based language instruction. Content-based language instruction and targeted instruction to develop skills in the language of instruction, is a popular approach used for English language learners in Canadian schools (OECD, 2006). Content-based instruction is an "umbrella term referring to instructional approaches that make a dual, though not necessarily equal commitment to language and content-learning objectives" (Stoller, 2008, p. 59). Additionally, differentiated instruction, which is instructional strategies, teaching and learning materials, and adjusted expectations in science, often place even less emphasis on reading for analysis, critique, and interpretation.

Aligned with the perspective of Phillips and Norris (2009), I believe that strong emphasis on hands-on activity in school science potentially de-emphasizes the centrality of reading to the fundamental sense of science literacy, and its role in inquiry. My intent in this dissertation is not to diminish the importance of authentic hands-on inquiry in science. Indeed, there is considerable support for the benefits of experiential learning starting from Dewey. Many authors, including Cuevas, Lee, Hart, Deaktor (2005), Kelly and Breton (2001), and Amaral, Garrison, and Klentschy (2002) suggest that inquiry-based science is a powerful instructional context that integrates academic content and language development for English language learners. It is not surprising then, the prolific use of inquiry as a teaching method in science for both English speaking students and English language learners. The problem is a one-dimensional perception of inquiry in school science, which is often viewed and described as a "hands-on activity". Often the "hands-on activity" is not rich authentic "hands-on inquiry". As Kim and Tan (2011) note, many hands-on activities in classrooms are 'fun' activities that tend not to engage students' minds and skills. They argue that the extensive availability of these types of highly structured practical worksheets "has led to the prolific practice of the 'cookbook' failsafe brand of practical work" (p. 466). In addition, this correlation between science inquiry and "hands-on-activity" is an association that does not reflect the importance of learning to read and write in science for meaningful learning and science literacy. My research problematic presupposes that school science can be a stultifying environment where the teacher heavily controls knowledge. Within this context, learning through inquiry is too often conducted with an emphasis on hands-on activities. This overemphasis leaves little room for the development of inquiry through reading and, therefore, implicitly de-emphasizes the importance of reading for the development of independent, autonomous thinkers for a scientifically literate populace.

1.5 The Study

As a science educator with an interest in reading and writing in science, the decision to implement an experiment in 'intellectual emancipation' in the science classroom was a likely choice. In addition, the subject of science is somewhat unencumbered by the pressures of provincial and school board testing in Ontario, Canada, where, unlike the subjects of math and language, allowed more flexibility to experiment with my teaching.

In *The Ignorant Schoolmaster,* Rancière (1991) argues that no person can emancipate another. However, to be the cause or agent of emancipation for someone requires one's *own* emancipation. According to Rancière, a teacher must begin by knowing him, or herself, "that is to say, by examining the intellectual acts of which [they are] the subject, by noticing the manner in which [s/] he uses, in these acts, [their] power as a thinking being" (Rancière, 1991, p. 36). Similarly, Habermas (1971) argues that knowing oneself comes from bringing intentional awareness to the processes, which form personal perspectives. It is only once self-reflection has occurred, can action be negotiated to correct social and individual pathologies.

Rancière guided my reflection on my practice as a teacher-researcher in this study through my reading of *The Ignorant Schoolmaster*. In the relationship between an *"ignorant schoolmaster"* and a student, learning occurs as the teacher verifies through questioning, that a student has searched for understanding. The guiding questions that Jacotot used with his students (What do you think of it? What do you make of it? What do you see?) are the questions that not only guided my reading and how I related to Rancière's text and associated literature for my own learning, but also acted as a lens through which I reflected on schooling, my teaching experiences, and my practice as I sought to find answers to my questions.

Looking at science inquiry in my practice through the lens of Rancière's (1991) philosophy offered alternative ways to theorize inquiry and rethink science literacy. It allowed me to rethink the notion of inquiry in my classroom, to reconceptualize inquiry as reading and a vehicle through which intellectual emancipation could be cultivated in science learning. This drew me to the work of Norris et al. (2008) who proposed a theoretical perspective of "reading *as* inquiry" in science. Their work forms the theoretical basis for this study. They posit, "reading is inquiry- analyzing, critiquing, and interpreting text involves the principled interpretation of text by a reader who infers meaning by integrating text information with relevant background knowledge" (p.770). Scientists and science learners interpret text when they read. Norris et al. (2008) argue that 'reading shares the features of all inquiry' and the complexity of interpreting a text can be seen in the processes of

> . . . taking into account all the relevant information; applying criteria for judging the adequacy of interpretations; and judging whether a proposed interpretation explains the text and is consistent with known facts, whether alternative

interpretations are inconsistent with known facts, and whether the proposed interpretation is plausible. (p. 770)

The experience of inquiry that I sought to cultivate is one that fostered 'intellectual emancipation' in students through reading in science. To this end, my research explores three main questions with a series of associated sub-questions. Within the context of this project:

1. **How did my practice respond to Rancière's notion of intellectual emancipation?**
   What is the model of practice that emerged?

2. **What are the effects of the changes in my practice on student learning?**
   In what ways do students demonstrate, or not demonstrate, their intellectual emancipation? How do students learn science concepts?

3. **What are the effects of these changes for teaching and learning?**
   In what ways do these changes influence my relationships with students? How does it affect my teaching belief systems? To what extent do I become using Rancière's term, an'ignorant schoolmaster'?

The theoretical perspective that reading *is* inquiry and Rancière's ideas on 'intellectual emancipation' inspired my response to the problematic and is the basis for my study. As an elementary teacher who has been teaching for 9 years, I recognize the complexity of studying idealized concepts and abstractions in complex social settings. Rather, this study investigates in what ways can 'intellectual emancipation' be encouraged or realized in students through the fundamental sense of science literacy, science inquiry, and liberation from stultifying practices in the classroom. What I offer is a tentative and ultimately pragmatic practical and situated response to Rancière's notion of 'intellectual emancipation' that takes the form of emergent pedagogy in my science classroom.

The sense of the unknown and being truly ignorant on this experimental journey was all at once intimidating and liberating. To embrace radical ideas counter intuitive to common teaching practices, and especially with English language learners, helped to create a true sense of inquiry for my students and me. Recognizing that 'intellectual emancipation' and stultification are not fixed points but are concepts that are best conceptualized on continuums, this study looks at taking measures to move teaching practices, students, and the teacher away from stultifying practices towards a way of thinking about learning and teaching in science that promotes 'intellectual emancipation' as a journey whose destination is always just on the horizon.

1.6 Introduction to the Following Chapters

This thesis comprises eight chapters. *Chapter 2* presents a literature review which first positions the study in the theoretical framework of intellectual emancipation as conceptualized by Jacques Rancière. Next, the review explores perspectives of inquiry in school science followed by a review of the literature on reading in science, and its relationship to the development of science literacy in school science.

In *Chapter 3*, I provide a historical context and philosophical rationale for choosing Action Research as a method for this study. Highlighting authors who were instrumental to Action Research development as a qualitative research method is used to outline the evolution of Action Research. I also draw attention to the influence of Action Research in the domain of science education. This review of Action Research in the literature provides a foundation for justifying the adoption of the research design in my study.

Chapter 4 outlines the methodology used in my study. The chapter starts with an overview of qualitative traditions of case study. I discuss the context in which case study is utilized in my research and then define *my* case as an action research project. I outline the research design and phases, instructional context, participants, data collection tools and the method of data analysis. I conclude the chapter by addressing ethical considerations.

In *Chapter 5,* I propose a pedagogical model in response to the prospects of emancipation within school science. The model explores the emancipatory possibilities afforded by a type of pedagogy promoting inquiry through interactions with science texts.

Chapter 6 is a descriptive chapter outlining my model of pedagogy in practice. My goal is to offer the reader an introduction to the educational experiment and present some reflections on what occurred.

Chapter 7 explores the experiment through analysis of the data and explores the efficacy of the experiment. The chapter analyzes and highlights particular features and outcomes of the pedagogical model, specifically the expressions of 'intellectual emancipation' observed in students.

In the *final chapter*, I reflect on the results and interpretations, offering some implications of the model for inquiry in science education.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Through a review of relevant literature in the field of science education, this chapter offers a response to the problematic. My response takes the form of three lines of reasoning. First, I present a brief history of the term 'emancipation' and generate an argument for fostering intellectual emancipation in students as a way to combat potentially stultifying environments of school science. Second, I justify the importance of inquiry in learning science and contrast conventional and alternative perspectives, focusing on progressive interpretations. Third, I make the case for reading as inquiry and a vehicle through which intellectual emancipation may be cultivated. By focusing on reading research in science education to conclude the chapter, I embed the investigation in the science literacy discourse by arguing the importance of reading to the fundamental sense of science literacy.

2.2 Emancipation in Education

As previously noted, I have chosen to explore the concept of intellectual emancipation from the stance of Jacque Rancière (1991) as articulated in the text, *The Ignorant School Master*. However, the concept of emancipation and its relationship to schooling has a long tradition. It is not my intent for this literature review to discuss all the various theoretical perspectives and approaches to emancipation in critical theory and practice. Rather, by way of a general overview of its conception in contemporary literature, my intent is to situate Rancière's work in the discourses of emancipation.

Misgeld (1975) brings attention to the fact that in the eighteenth century emancipation became intertwined with the Enlightenment movement under the influence of authors such as Kant. Misgeld notes that Kant's (1784) essay *Answer to the Question: What is Enlightenment?* unfolds the connected nature of his ideas of emancipation, reason, and education. Misgeld (1975) contends that, for Kant, enlightenment is "the emancipation of man from a state of self-imposed tutelage, of incapacity to use his own intelligence without external guidance" (p. 24). Education is self-education from this perspective. The act of "becoming educated, or daring to use one's own intelligence, is the essence of enlightenment emancipation" (p. 24). Thus, Kant defined the age of enlightenment with the phrase *"Dare to Know"*. Misgled (1975) states:

> If detailed historical research should bear this out, we could interpret Enlightenment emancipation as dependent upon a concept of rationality that entails three features: (1) Knowledge must be self-discovered. (2) This discovery occurs when thought is based on universal principles of reason, for in following them, we subject ourselves only to procedures that everyone else must follow as well. . . . (3) Reason must be public. (p. 24)

Biesta (2010) adds that Kant defined 'maturity' in terms of rationality, the 'proper' use of one's reason, and rationality as the basis for independence and autonomy. As a result, a Kantian perspective views education as the lever for the transition from 'immaturity' to 'maturity' and this view shaped the development of education as an academic discipline. As Biesta notes, after World War II educators and philosophers began to shift their thinking and proposed that individual emancipation could not exist without wider societal transformation. For example, "in Germany, a major contribution came from Mollenhauer, whose critical-emancipatory approach drew inspiration from the early work of Habermas" (Biesta, 2010, p. 43).

The focus of emancipation in critical theories of education often involves an analysis of oppressive structures, practices, and theories. The contention is that emancipation cannot be attained if people do not gain adequate insight into the power relations that constitute their situation. Marx contributed to critical and emancipatory pedagogy with the concept of "ideology" (Biesta, 2010). Marx conceived ideology as a false consciousness that distorts social and material reality, functioning to keep people in their place within the capitalist system. Ideologies are not autonomous; they depend on the prevailing economic mode of production and serve as a justification for its continued existence (Dimitriadis & Kamberelis, 2006). This distorted reality prevents people from seeing relations of production as they truly are. Therefore, ideology is an aspect of superstructure: it is produced by the economic base and functions to legitimate that base (Dimitriadis & Kamberelis, 2006). For example, political, legal, family, press, and education systems are all rooted, to the class nature of society, which is a reflection of the economic base. Marx argued that the economic base or infrastructure generated or built upon itself a superstructure that kept it functioning. Therefore, the education system being part of the superstructure was a reflection of the economic base and served to reproduce it (Burke, 2000). In other words, the institutions of society, like education, are reflections of the world created by human activity and that ideas arise from and reflect the material conditions and circumstances in which they are generated (Burke, 2000). Similarly, Biesta (2010) suggests that:

> . . . it is precisely because of the way in which power works upon our consciousness that we are unable to see how power works upon our consciousness. This implies that in order to free ourselves from the workings of power we need to expose how power works upon our consciousness and that in order for us to achieve emancipation, someone else, whose consciousness is not subjected to the workings of power, needs to provide us with an account of our objective condition. . . . [I]n the Marxist tradition this position is considered to be occupied by science or philosophy. (p. 44)

As Galloway (2012) contends, in education, more contemporary authors such as Freire conceptualize the process of oppression "as a form of knowledge transmission that encourages students to be dependent upon teachers" (p.181). Noting that Freire (1972) coined the term "banking education" to describe this form of oppression where teachers deposit or channel knowledge directly into students' consciousness, she explains:

> This is activity blocks dialogue and in so doing disrupts praxis, enforcing a dichotomy between people and the world so that they cannot intend upon reality through their own choices and decisions. The oppressed, as students, are no

longer able to reflect and act together; instead, they are dependent on oppressors, as teachers, for their knowledge of the world. (p. 181)

Galloway (2012) further notes that according to Freire (1972), the inequality replicated in the dependent student/teacher relationship and knowledge transmission should be overcome by emancipatory education. It requires the teacher to "initiate dialogue in a relation of love that re-instigates praxis, so removing the dichotomy between people and the world" (p. 182).

Authors such as Kant (1784), Mollenhauer (1969, 1983), Habermas (1970, 1971), Freire (1970, 1976) and their contemporaries (Apple, 2004; Anyon, 2005; Bourdieu & Passeron, 1979) strongly influence the understanding of emancipation in the literature. Their conceptions form a certain modern logic of emancipation that informs progressive pedagogy today (Biesta, 2010). Biesta (2010) highlights contradictions that permeate both the logic and pedagogy of how such emancipation has been conceptualized. There are four main areas of contradiction. First, emancipation requires an external intervention. That is, an intervention by an authority that is not subjected to the power(s) that needs to be overcome. In this light, emancipation is something that is done to another. Second, the act of emancipation perpetuates dependency although it is oriented towards equality, independence, and freedom. The oppressed person is dependent upon the intervention of the emancipator. The third area of contradiction is the fact that there is a fundamental inequality between the emancipator and the one to be emancipated. It is the emancipator who knows best due to their inaccessible knowledge. And fourth, although emancipation is to take place in the interest of the emancipated, the act is based on distrust and suspicion regarding the oppressed experiences. In other words, the one to be emancipated cannot truly trust their senses, but rather, need someone else to inform them about what it is they are experiencing or expose the workings of power.

Rancière, as Biesta (2010) continues to argue, rejects these implicit contradictions in the traditional notion of emancipation and reconceptualizes emancipation from the standpoint of equality. Whereas traditional emancipation effectively presumes inequality in the emancipatory act in which an intervention from the outside makes a person equal, for Rancière emancipation simply means to act on the basis of the presupposition of equality. In this regard, Rancière conceives emancipation as something that people do themselves. According to Rancière, Galloway (2012) notes, "emancipatory education must reinstate the equality of intelligence, where the will of the teacher demands students to direct their own intelligence while acknowledging the intelligence of others" (p. 182).

2.3 Applying Intellectual Emancipation to Science Education

Intellectual emancipation becomes relevant to science education when one considers the following observation on learning in schools. Alsop and Bowen (2009) comment that:

> Schooling defines, demarcates and enacts what it means to be knowledgeable as well as what it means to be ignorant. Social institutions set up the obstacles and barriers that must be accomplished in moving from weakness to strength, inferiority in the face of knowledge, and perhaps even more significantly inferiority in the face of institutions that control knowledge, to their possible domination. This is how science and students become schooled. It is also how science education becomes a part of the process of schooling society. (p. 58)

The potential lesson for science educators is that school systems and educators may in fact create the conditions for powerlessness in students and control students' creative powers (Bazzul, 2013). This study in intellectual emancipation is a response to science learning environments where learners may be 'stultified' as a result of the traditional power and control dynamics of schooling. According to Rancière, in such environments educators operate under the premise that students cannot understand without the explanations of the teacher. If the student does not understand, the teacher employs new more rigorous and attractive ways to explain. The principle of explication forms this approach, which implies, an assumption of inferiority of the student. Rancière reasons, "to explain something to someone is first of all to show him he cannot understand it by himself" (p.6). He notes that the explicating teacher keeps the student aware of their intellectual inferiority by keeping back a piece of learning. Schooling exemplifies the standard and typical approach to teaching which is often characterized by the transmission of knowledge adapted to the intellectual capacities of students and delivered through an ordered progression of simple to complex. For example, referring to school science, Alsop and Bowen (2009) note:

> Learning science in the twenty first century is now neatly age delineated with precisely graduated learning outcomes/indicators identified for each age, spanning kindergarten to grade 12. Teachers are required to (usually legally) measure and report students' progress (or not) against these indicators irrespective and independent of children's individual developmental trajectories. Although the ordering of content in the curriculum has been shaped through extensive collaboration, the dilemma is not the content per se, but the way in which it is tightly equated with age grade. As all educational research attests, school grade, experience, and maturation are very different; one age referenced 'curriculum statement' rarely fits all; indeed it actually fits few. (p. 51)

Safstrom (2011), echoes this sentiment and suggests that developmental psychology:

> . . . incorporates the very idea of limitation of the transmission of knowledge in order to transmit knowledge only in accordance with the current stage of inequality of the child. What developmental psychology does in education is to organize an infinite delay of equality and to explain the deferral through the 'natural' development of the child. Developmental psychology applied to education is an example of what Rancière (2010) calls the pedagogical paradigm that ''translates to a general model of society ordered by progress" (p.8). The master teacher who reduces knowledge to stages, according to the best methods known and only to those who are unequal, confirms inequality and defers equality to a distant future. (p. 207)

This perspective highlights some of the structural tensions that practitioners are facing, although, of course, it is not the complete picture. According to Rancière, this world of school science may tie students to the explicative practices that stultify. The stultification of students that arise from this schooling context is not due to the lack of instruction, but the belief in the inferiority of their own intelligence. It is a world in which "explication is the myth of pedagogy, the parable of a world divided into knowing minds and ignorant ones, ripe minds and immature ones, the capable and the incapable, the intelligent and the stupid" (Rancière, 1991, p.6).

In contrast, autonomous and independent thinkers may be developed through what Rancière terms 'universal teaching'. That is where the teacher believes a student can learn and obliges them to use their own intelligence and realize their capacity. As Rancière (1991) writes, "what stultifies the common people is not the lack of instruction, but the belief in the inferiority of their intelligence" (p. 39). As Biesta (2010) restates, "the only thing that is needed is to remind people that they can see and think for themselves and are not dependent upon others who see and think for them" (p. 55).

Therefore, instead of inequality, Rancière proposes the presupposition of the equality of intellectual capacity of all. That is equality as the starting point and not the end result; a complete act or nothing at all. Adopting the belief that there is no hierarchy of intellectual capacity and perceiving education, not as the process of filling up the 'blank slate' of a student's mind with knowledge, one can accept that education is the matter of what all students equally have, a baseline of intelligence. Any difference is a result of differing levels of effort among learners (Liang, 2009). As a result, "equality is not achieved as an end product of a series of stages but is confirmed by emancipated individuals, that is, by individuals who have discovered their equality with everyone else in the demos, regardless of status, wealth, and power . . . " (Safstrom, 2011, p. 207).

Consequently, emancipation is not something "*given* by scholars, by their explications *at the level of* the people's intelligence, but . . . seized, even against the scholars, when one teaches oneself" (Rancière, 1991, p. 99). Rancière contends "[t]here are a hundred ways to instruct, and learning also takes place at the stultifiers' school . . ." (Rancière, 1991, p. 102). However he notes, "whoever emancipates doesn't have to worry about what the emancipated person learns. He will learn what he wants, nothing maybe. He will know he can learn because the same intelligence is at work in all the productions of the human mind, and a man can always understand another man's words" (p. 18). Therefore, emancipation in the classroom is directed to the individual. Learning is about using one's intelligence under the assumption of the equality of intelligence. In contrast emancipation is not directed towards society at large. As Rancière states, "one only needs to learn how to be equal men in an unequal society. This is what *being emancipated* means" (Rancière, 1991, p. 133).

2.3.1 Intellectual emancipation, teaching, and learning. The beauty of this philosophical perspective is not to prove that all intelligence is equal. It is, to use Rancière's words once more "seeing what can be done under that supposition" (Rancière, 1991, p. 46). For Rancière equality comes from recognizing that, for anyone who has learned to speak, intelligence is the capacity to engage with the world and its objects in a meaningful way. This is by being obliged to relate what one does not know to what they know, to observe and compare, and to verify what was seen and said. For example, all people have the capacity to engage the same material object (e.g., a book). Therefore, equal access to the same object and the capacity to engage it in a meaningful way is equal. Rancière does not presuppose that everyone in the world has equal opportunities to learn and to express their capacities. For instance, an obstacle to learning may occur because an individual may think it is not possible or necessary to know more. The predominant pedagogic logic says that people are ignorant and that they do not know how to get out of ignorance to learn. As Rancière in his interview with Liang (2009) notes, "this establishes the need for some kind of an itinerary to move from ignorance to knowledge, starting from the difference between the one who knows and the one who does not know".

This type of emancipatory teaching (universal teaching) presupposes equality of intelligence where the application of or access to intelligence is a matter of will. Therefore, learning, from this perspective, is an act of will, "whether the will compels or relaxes the workings of the intelligence" (Rancière, 1991, p. 56). In other words, learning is the training and strengthening of will. According to Rancière (1991), "intelligence is attention and research before being a combination of ideas. Will is the power to be moved, to act by its own movement, before being an instance of choice" (p. 54). Rancière argues that each of us represents a will that is served by intelligence. We see, analyze, compare, reason, correct and reconsider, on an everyday basis. We do not always learn the same things because we do not pay the same amount of attention to the situation. Furthermore, he suggests that:

> . . . [m]eaning is the work of the will. This is the secret of universal teaching. It is also the secret of those we call geniuses: the relentless work to bend the body to necessary habits, to compel the intelligence to new ideas, to new ways of expressing them; to redo on purpose what chance once produced, and to reverse unhappy circumstances into occasions for success. (Rancière, 1991, p. 56)

For example, a student may need a master when their own will is not strong enough to set them on track and keep them there. This subjection is purely will over will. It becomes stultification when it links intelligence to another intelligence, that is, what the teacher knows and/or allows a student to know. As Rancière notes, in Jacotot's situation the students were linked to a will (Jacotot) and to intelligence (the book). A Rancièrien view of intellectual emancipation is the *known* and *maintained* difference of the two relations.

To elaborate, I draw from Ruitenberg (2008) who highlights Rancière's perspective on the two fundamental differences in the teacher-student relationship. First, the difference between teachers and students is one only of will, not intelligence. The teacher assumes that the student is capable of learning and understanding and simply tells the student to study the work. Instead of holding the student back from learning under the premise of protecting them from the frustration of encountering material that is too difficult too soon, the teacher encourages the student to use the same intelligence they used for learning many other things without explications: by paying close attention, comparing, and verifying. Therefore, a teacher teaches by being a *cause* of knowledge for another person without transmitting knowledge. Second, Rancière implies an equal one to one relationship between students and the author of the text. The following section explores this relationship.

2.3.2 Intellectual emancipation through text. For Rancière (1991), "[t]here is nothing behind the written page, no false bottom that necessitates the work of an *other* intelligence, that of the explicator [teacher] . . ." (p. 9). The first principle of emancipatory learning is that one must learn something and relate everything else to it. This requires a student to "talk about everything he learns - the form of the letters, the placement or ending of words, the images, the reasoning, the characters' feelings, the moral lessons - to say *what he sees, what he thinks about it, what he makes of it*" (p .20). Subsequently, a student must be able to show, in the text, the materiality of everything they say, when writing in response to the text, a student must use the language and constructs of the text to demonstrate from the text the facts on which their reasoning is based (p. 20). Students "must see everything for [themselves], compare and compare, and always respond to a three part question: What do you see? What do you think about it? What do you make of it?" (p. 23). In this way, students verify the work of their intelligence and their intelligence is revealed to itself (p.28). In Rancière's words, "[a]ll knowledge of oneself as an intelligence is in the mastery of a book, a chapter, a sentence, a word" (p. 26).

Rancière asserts that any writer, despite their personal views on equality, write under the assumption that any reader given the will, opportunity and need could understand their written expression. With Rancière's emancipatory approach, the teacher provides the occasion and verifies that the students' will and intelligence remain committed to '*the search*'. Understanding comes through repetition and questioning. Not Socratic questioning, where the teacher already knows the answers, but questions that elicit responses that are the measure of students' sincerity.

Emancipatory teaching differs radically from the Socratic method. In the latter, through questioning, students are *led* to recognize 'truths', conclusions, and knowledge that Rancière hypothesizes, lie within themselves. Rancière argues that this is a path to learning, but is in no way the path to intellectual emancipation. In applying the Socratic method, "the demonstration of [a student's] knowledge is just as much the demonstration of his powerlessness: he will never walk by himself, unless it is to illustrate the master's lesson" (Rancière, 1991, p. 29). In contrast, Rancière describes the secret to a good teacher in the emancipatory approach in the following manner, "through their questions, they discreetly guide the student's intelligence-discreetly enough to make it work, but not to the point of leaving it to itself" (Rancière, p. 29).

2.3.3 Intellectual emancipation and the use of the necessary habits. As discussed, Rancière claims that a student could learn by themselves without explicative supports from a teacher and that the key to emancipatory learning lies in the relationship of will between teacher and student. Additionally, Rancière refers to a student's *attention and research* and the *necessary habits.* In the following project, I interpret these necessary habits as the skills and abilities required to be intellectually emancipated through text. I make the assumption that the capacity to learn is supplemented by the will to learn and the development or use of specific skills and abilities. As my dissertation unfolds, I focus on two particular 'habits', both of which have an established history in educational research. They are a student's ability to analyze text and student's use of metacognitive strategies.

Text analyst. In order to develop the skills and abilities of a text analyst as it pertains to reading in science, students require many opportunities to engage with science text beyond the surface level. Students need to develop their skill as text analyst by understanding that the text is a crafted object of communication, made by an author who has particular ideologies or set of assumptions from which their reasonings are constructed. In this regard, it means cultivating an understanding that all texts regardless of how authoritative they appear, present a view of the world and that readers are positioned in a certain way when they read it.

Based on my teaching experience I believe students, especially English language learners, are not sufficiently challenged to interact with text in this manner. In her seminal study, Durkin (1978/1979) revealed that teachers most often employ the direct reading lesson to develop reading comprehension as often expounded in teacher education faculties. Variations of this method, where a teacher introduces a reading selection to students, guides their reading of the text, and then discusses the reading with them is still common today in science classrooms. This approach to reading instruction offers few tools that students can use independently to facilitate their own reading compression. In short, the students are left in a teacher-dependent state. Further, Fang and Wei (2010) cite DiGisi and Willett's (1995) survey of high-school biology teachers which illustrated that even when teachers believe that reading is a valuable means of learning science, they are unsure about how to incorporate active reading comprehension instruction into their science curriculum. Teachers reported "their common practices involving reading included the pre-teaching of vocabulary, asking questions while students were reading, assigning worksheets after reading, writing answers to questions after reading, and quizzing students after reading" (Fang & Wei, 2010, p.265).

Phillips and Norris (2009) argue that students should learn to adopt a critical stance toward science text by engaging in interactive negotiations between the text and their background knowledge in an attempt to reach an interpretation. Students' cultural capital and prior knowledge becomes a vital asset to their learning since reading as inquiry, and universal teaching recognizes that there is always something one knows that can be used as a point of comparison to relate to new learning. Consequently, learning depends on what the reader brings to the task in terms of conceptual understanding, text interpretation strategies and background knowledge. Interpreting what one reads is "dependent upon relevance decisions all the way down to the level of the individual word; and it requires the active construction of new meanings, contextualization, and the inferring of authorial intentions" (Norris & Phillips, 2003, p. 229). Although reading is a constructive process, "reading is constrained in its possibilities. Completeness and consistency are the two main criteria for judging interpretations. Readers must ask which interpretation is more complete and more consistent. They are thus foreclosed from offering just any interpretation at all" (Phillips & Norris, 2009, p. 318). In a similar vein, Hand, Alvermann, Gee, Guzzetti, Norris, Phillips, Prain, & Yore (2003) note, "science literacy must imply that the very words and other textual elements matter as constraints on allowable interpretation that readers are obliged to take into account. Some interpretations, if not impossible, are highly implausible" (p. 612).

Making sense as one learns through reading requires the learner to organize the information from the experience in schemas or an explanation that fits their logic and/or real world experiences. As McTavish (2008) explains, each person structures his or her own knowledge of the world uniquely and connects each fact, experience, or understanding subjectively. From the perspective of constructivist theory, a person learning something new brings to the experience all of their previous knowledge and current mental patterns. The process and structure for each individual is constantly and actively modified in light of new experiences. However, the organization of existing knowledge influences the construction of new meaning or comprehension. The reading process is an interactive and constructive as readers make sense of the text. Drawing on the work of Baker and Brown (1984), McTavish (2008) notes all theories of reading involve metacognition as a constructive process.

Metacognition. The concept of metacognition has fascinated scholars in many disciplines throughout history. In a review of metacognition, Yuruk, Beeth, and Andersen (2009) describe its broad and multiple dimensions. They refer to one's "inner awareness" about learning processes, what one knows or one's current cognitive state, "knowledge about knowledge", "reflections about actions", and the process of "thinking about one's own thinking". Or as Michalsky, Mevarech, and Haibi (2009) explain, it is the conscious self-awareness of one's own knowledge of a task, topic, and thinking and the conscious self-management (executive control) of the related cognitive processes. The motivation to complete a task, planning, monitoring comprehension, and evaluating the task are all examples of metacognitive skills employed by effective learners. For instance, Yore and Treagust (2006) explain, "from a science education researcher's perspective, metacognition deals with students' understanding and is a consideration of how their thinking influences their inquiries, actions, and learning as well as helping students develop their understanding of the scientific concepts, which in turn can lead to enhanced science literacy" (p. 306).

Yuruk, Beeth, and Andersen (2009) argue that "based on the key characteristics of metacognition - an acquired knowledge about one's cognition, awareness of one's personal stock of information and one's control and regulation of cognition - metaconceptual knowledge and processes can be classified into four components: metaconceptual knowledge, metaconceptual awareness, metaconceptual monitoring, and metaconceptual evaluation" (p. 452). Yuruk et al. (2009) submit that metaconceptual knowledge is acquired through experiences, stored in memory and can be retrieved explicitly or implicitly as required. It is knowledge about concept learning and the factors influencing its formation. The authors state that, "metaconceptual awareness is one's awareness of and reflection on existing and past concepts and elements of conceptual ecology, including one's interpretation of experiences, ontological and epistemological presuppositions, and the context in which a concept is used" (p. 453). This is expressed when a person recognizes "the elements of her/his existing conceptual structure" or when individuals make "reference to her/his past conceptual structure (e.g., "I used to believe that force was necessary to keep an object moving.")" (p. 453).

Yuruk et al. (2009) suggest that metaconceptual monitoring and evaluation are part of the processes that individuals engage in during their attempt to learn a subject. The former is

> . . . an "online" process, which generates information about one's cognitive state or thinking process. Examples of the monitoring processes are monitoring information coming from other people or sources, the comprehension of conceptions, the consistency between the existing and new conception, and changes in ideas (e.g., "I think I do not understand Newton's Third Law. I know this because I cannot explain it to someone else."). (p. 453)

The latter is

> . . . a learners' judgments about the relative ability of the competing conceptions to explain the real phenomenon. Learners make judgmental decisions about competing conceptions in different forms. They may make comments about the relative plausibility, usefulness, and validity of existing and new ideas (e.g., "I

> thought that force is necessary for motion. During class discussion someone told me that an object might not necessarily move even though force acted on it. This idea is attractive to me because when you push a heavy object like a car it does not move."). (p. 453)

In so doing, Yuruk et al. (2009) note that students choose one idea over others as they evaluate and justify why one is more appropriate than the others in a given context.

The metacognitive skills that learners use to monitor and regulate their reading processes cultivate some of the abilities necessary to develop competence in inquiry tasks and to read science texts. Michalsky, Mevarech, and Haibi (2009) support this view by highlighting the work of authors such as Quinn and Wilson (1997) who (1) proposed that a student's use of their metacognitive skills should enable them to think about how they comprehend a text and what they should do next; and (2) provide the opportunity to reflect on what they have learned or on mistakes they have made. DiGisi and Yore (1992) also promote these ideas in their belief that metacognitive skills facilitate students recognizing what they know about a topic, what they do not understand, and what they still need to know to remediate discrepancies in their understanding. Metacognition can also be seen to indicate a student's capacity to use scientific knowledge. That is to "identify questions and draw evidence-based conclusions; to make critical judgments about what to believe or to do; to make decisions about the natural world and the changes made to it through human activity; and to reflect on these actions" (Yore & Treagust, 2006, pp. 306-7). As Yore and Treagust (2006) postulate, understanding metacognition from this perspective suggests a convergence of learning metacognition, critical thinking, and reflection.

2.3.4 Summary. Presupposing equality of intellectual capacity of all people is requisite to build an environment that cultivates intellectual emancipation. In this environment, teachers hold the belief that students will learn by themselves and in response, students exercise their own intelligence to learn propelled by their will to learn, attention, research, and necessary habits. Students are on their **own** path or route to learning and are kept there by linking their will to the teachers' when their will is not strong enough. In this regard, a teacher's art is to help students prove that they have studied attentively by bringing them back to the text to verify their learning. This relationship between emancipatory pedagogy and text, as discussed in this section, has unique implications for science inquiry. In the following sections of the literature review, I will propose a less common view of inquiry that offers emancipatory possibilities. First, I will discuss more traditional aspects of inquiry in science.

2.4 Intellectual Emancipation Through Inquiry

2.4.1 Conventional perspectives of school science inquiry. In many counties, the term inquiry is widely used and frequently advocated by science educators and promoted as a goal in policy and curriculum documents. Alsop and Bowen (2009) note that a closer inspection of policy reveals that the term has become confused; in the science education literature studies have misrepresented inquiry and used inquiry to misrepresent science. Adding to the confusion are vague definitions of inquiry that equate inquiry with primarily hands-on activity. Howes, Lim, and Campos (2008) comment that this lack of agreement may be unavoidable and necessary. They cite Keys and Bryan (2001), who state, "[t]eaching actions will necessarily differ based on factors in the local environment, such as teacher knowledge, student age [and] student language proficiency . . ." Therefore, "inquiry is not a specific teaching method or curriculum model" (p. 190).

Bybee, Powell, and Trowbridge's (2008) review of inquiry recognizes that the concept has evolved over the past century. They acknowledge Dewey's role in the introduction of inquiry into the school science curriculum, noting that, as early as 1909 Dewey argued that science teaching should be approached as a method of inquiry. Barrow (2006) notes that for Dewey, students are to be actively involved in their learning, and the teacher's role is one of facilitation and guidance. For example, students "address problems that they want to know and apply it to the observable phenomena … problems to be studied must be related to students' experiences and within their intellectual capability; therefore, the students are to be active learners in their searching for answers" (p. 266).

Barrow (2006) explains that inquiry science gained momentum with the 1958 Rockefeller Report, following the launch of Sputnik I in 1957. Further, in the 1960's Schwab (1960) supported the use of inquiry for teaching science and identified two types of inquiry; "stable (growing body of knowledge) and fluid (invention of new conceptual structures that revolutionize science)" (p. 266). Schwab not only encouraged the use of laboratories to facilitate students in their study of science concepts, but also encouraged the use of reading reports or books about research, having "discussions about problems, data, the role of technology, the interpretation of data, and any conclusions reached by scientists". Schwab called this "enquiry into enquiry" (p. 266). As the decades progressed, inquiry science has become a pillar of much school science.

Many authors have proposed various definitions of inquiry. For example, Barrow (2006) cites Minstrell (2000) as listing several different definitions of inquiry which include:

> . . . encouraging inquisitiveness (habits of the mind), teaching strategies for motivating learning, hands-on and minds-on, manipulating materials to study particular phenomena, and stimulating questions by students. [Minstrell] considered inquiry to be complete when we should know something we did not know before we started. Even when our investigation fails to find the answer, at least the inquiry should have yielded a greater understanding of factors that are involved in the solution. (p. 265)

Zion, Cohen, and Amir (2007) also refer to Minstrell (2000) as stating that during the inquiry process "we need to encourage and support personal curiosity when it occurs spontaneously and stimulate it when it doesn't occur naturally" (p. 424).

In school science, inquiry-based teaching often refers to the learner constructing understanding as they explore a question about the world. According to Wang, Wang, Tai, and Chen (2010), the National Research Council [NRC] (2000) draws a parallel between scientific and school science inquiry:

> . . . while *scientific inquiry* refers to the systematic approaches used by scientists in an effort to answer their questions about the world, *school science inquiry* refers to a pedagogical approach that reflects the nature and practice of science in which learners engage scientifically oriented questions, give priority to evidence, formulate explanations from evidence, connect explanations to scientific knowledge, and communicate and justify explanations. (p. 802)

Inquiry-based approaches in school science encompass a broad spectrum of guidance afforded to students as they learn. For example, this is seen in the literature with the popularity of Schwab's (1962) scale of inquiry approaches in science instruction (Table 1). This framework is structured around three components of scientific investigation: a) problems, b) ways and means for discovering relations, and c) answers or results. In this scale, Level 0 is the lowest level of inquiry in which the teacher has a great control over questions, methods, and interpretations. At the highest-level students control all three components.

Table 1
Schwab's Scale of Inquiry Approaches in Science Instruction

Level	Problem	Method	Results/Conclusions
0	Given	Given	Given
1	Given	Given	Open
2	Given	Open	Open
3	Open	Open	Open

Similarly, Wang et al. (2010) cite Colburn (2000) who classified inquiry in school science into four categories based on the level of student involvement: structured inquiry, guided inquiry, open inquiry, and learning cycle. Wang et al. (2010) maintain that the most common type of inquiry found in the exercises of laboratory and field manuals is structured inquiry. Here, the problem is stated, or the question/hypothesis formulated by the teacher and the method provided. The students implement the method, gather and analyze the data, and draw conclusions. In contrast, guided inquiry provides only the problem posed by the teacher. The students determine the methods and solution. Alternatively, open inquiry focuses on the inquiry process. The science content is dependent upon the aspect of the phenomenon that students choose to investigate. In open inquiry students are given the phenomena and are required to state the problem, formulate the hypothesis, choose the method, and find the solution. Finally, learning cycle lessons engage a phenomenon, explore a problem, formulate and apply a concept, and assess students' understanding (Wang et al., 2010; Zion, Cohen, & Amir, 2007).

To aid in describing and identifying inquiry-based science teaching in various learning environments, the NRC has identified five distinguishing features of inquiry (NRC, 2000, p. 25):

1. Learners are engaged by scientifically oriented questions;
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions;
3. Learners formulate explanations from evidence to address scientifically oriented questions;
4. Learners evaluate their explanations in light of alternative explanations, particularly those that reflect scientific understanding; and
5. Learners communicate and justify their proposed explanations.

The framework allows for a range of inquiry practices that may vary with the level of guidance by the teacher in each of the five areas. Although there is much debate around what constitutes inquiry-based science teaching, many in the research community view these five characteristics as capturing the fundamental elements of inquiry science in the classroom. Alternatively, Abd-El-Khalick, Boujaoude, Duschl, Lederman, Mamlok-Naaman, Hofstein, Niaz, Treagust, and Tuan (2004) suggests that "instead of thinking of a generalized image of inquiry in science education and assuming it will allow achieving multiple goals, it might be more useful to think of several images of inquiry that are intimately linked with small clusters of valuable instructional outcomes" (p. 415). The authors argue "[w]hat is needed is a sort of a multidimensional heuristic that defines a space of outcomes, which would facilitate discourse and streamline communication about images of inquiry between players within any educational setting. . . ." (p. 415). They propose four possible dimensions:

1. Knowledge and understanding in the realm of concepts and problem solving;
2. A range of inquiry-related activities;
3. A range of skills such as mathematical, linguistic, manipulative, cognitive and metacognitive skills, needed to meaningfully engage in inquiry;
4. A range of spheres such as, personal, social, cultural, and ethical that would interface with any of the previously mentioned outcomes.

Difficulty with inquiry. Many researchers have studied barriers that influence teachers implementing inquiry practices into their science teaching. For example, Anderson (2002) contends that many teachers have a false conception of inquiry and an incomplete understanding of how to teach students about it. He describes three of these barriers as technical, political, and cultural dilemmas. In addition, Crawford (2007) cites the work of authors such as Bryan (2003), and Wallace and Kang (2004) who discovered that teachers interested in using inquiry practices held competing sets of beliefs. Similarly, evidence from Crawford's (2007) own study emphasizes the fact that a strong predictor of a prospective teachers' actual practice of teaching science as inquiry is based on a complex set of personal beliefs and their views about teaching and views of science. This view is comprised of their knowledge of scientific inquiry and inquiry-based pedagogy, and their belief of teaching and learning. Welch, Klopfer, Aikenhead, and Robinson (1981), as cited in Barrow (2006), identified other factors such as "limited teacher preparation, including management; lack of time, limited available materials; lack of support; emphasis only on content; and difficult to teach" (p. 267).

Inquiry based science and English language learners. Advocating for a more balanced view of the fundamental sense of science literacy does not mean that I am dismissing the significant work that highlights the importance of hands-on inquiry learning for English language learners in science education. There is a preponderance of literature (Garcia et al., 2001; Gibbons, 2004; Kelly & Breton, 2001; Lee et al., 2008 as cited in Howes et al., 2008) in the field of science education and English language learners that promote the participation of such learners in challenging scientific inquiries as they learn English; the benefit being to both their language and science learning. A similar body of work (Garcia et al., 2001; Gibbons, 2004; Stoddart et al., 2002; Zuniga et al., 2005 as cited in Howes et al., 2008) contends that English language learners do not need to be proficient in English prior to productively engaging in content-based learning. Lee, Buxton, Lewis, and LeRoy (2006) note that a growing number of researchers have focused their attention on students from diverse languages and cultures to promote science inquiry. They comment:

> This research points to the need for teachers to recognize the intellectual resources that these students bring to school science, to incorporate linguistic and cultural funds of knowledge that diverse student groups bring to the classroom, and to examine how students' everyday knowledge and language intersect with scientific practices. (p. 609)

More specifically, researchers have also focused on the benefits of hands-on inquiry-based science instruction and English language learners (Amaral, Garrison, & Klentschy, 2002; Casteel & Isom, 1994; Merino & Hammond, 2001; Stoddart, Pinal, Latzke, & Canaday, 2002 as cited in Lee et al., 2006). For example, Rodriguez and Bethel (1983) studied the effectiveness of an inquiry approach to science and language teaching with grade three students. The experimental group participated in science inquiry lessons requiring them to manipulate objects, explore and interact with peers and the teacher. The control group was taught with traditional science lessons. The researchers found that students in the experimental group improved in classification and oral communication skills. Further, Merino and Hammond (2001) studied how elementary teachers facilitated science learning with English language learners through writing. Teachers implemented a science-based interdisciplinary approach with English language learners in which a series of science inquiry lessons were integrated with other subjects of the school curriculum. The students showed improvements in writing skills that also demonstrated scientific understanding. The researchers advised that students should be provided with opportunities to write in genres other than narrative texts in content areas such as science (Lee, 2005).

Researchers tend to promote hands-on activities citing three general reasons: a) less dependency on formal mastery of English thus reducing the linguistic burden on students, b) hands-on activities through collaborative inquiry supports language acquisition in a context of authentic communication in science, and c) inquiry-based science teaching provides learners with a variety of formats (written, oral, gestural, graphic) to communicate their understanding (Lee et al., 2006).

2.4.2 Alternative perspectives of school science inquiry. As a response to what I believe to be an overemphasis on hands-on inquiry-based science activity for English language learners, and embracing the emancipatory opportunities afforded by alternative perspectives of inquiry, I explore two progressive perspectives of science inquiry in this section.

Some researchers (Illich, 1971; Postman & Weingartner, 1969) espouse a more dynamic, general and progressive view of inquiry. Among them are Alsop and Bowen (2009) who believe "inquiry is an expression of creativity, imagination and freedom – learners undertaking something new, something unforeseen by us. It is about offering the young democratic opportunities to create their own knowledge, shape their own experience and follow their own questions, desires and inspirations in search of novel answers and actions" (p. 49). The contemporary interpretation of the conventional view of science inquiry in school settings tends to focus on learning the discipline of science in terms of acquiring the products (content) and processes (skills) of science through mostly teacher-centered didactic methods and approaches – usually in the form of following instructions on predetermined worksheets. This may be attributed to the volume of content to be covered creating reliance on these pre-determined and pre-programmed learning resources (Alsop & Bowen, 2009). A dynamic or progressive view of inquiry is learner centered, focusing not only on the subject, but also on the personal growth and development of the child. The authors point out that it is equally beneficial to recognize the social transformation, which is the multiple ways that our practice shapes schools and their relationship with society. These three referents (subject, child, society) of education are entwined throughout our practices as science educators, and yet emphasized and valued differently. As Alsop and Bowen (2009) note, "school science cannot be simply interpreted with referent to covering a subject area without concomitant consideration given to its connections to child development and society" (p.58).

Placing more value on the learner and society in an educational era in which the emphasis and attention are often on covering the basics, mastery of subject content knowledge and an environment of standardization and accountability, puts this more progressive and balanced view of inquiry in opposition to conventional views (Alsop & Bowen, 2009). To advance this more dynamic view of inquiry in school science, in a culture where compliance is the norm, requires breaking through the taken for granted assumptions of everyday practice and questioning the dominance of the conventional perspective. From Rancière's philosophical perspective, this is 'politics'; the interruption of the normal consensus (Rancière, 1999). According to Rancière (1999), politics is the disruption of the 'police order' in the name of equality. Rancière uses the term 'police order' to describe the process of governance that prescribes what can be seen, said and done, what is allowed or not allowed in any given situation. It is similar to a code of conduct that creates a permanent set of norms which in turn establish a community that decides who is included or excluded, whose words are significant or insignificant, and who is entitled to govern others and who is not. Maintaining this system is the 'police'; the power that keeps everyone and everything in its place. Alsop and Bowen (2009) note "that the struggle for inquiry and many of the ideas that we hold dear in science education (child-centered pedagogy, science for all, social justice and equal opportunities) are part of a broader struggle - a social coalition for changes in schooling" (p. 59). The idea of a social coalition for change towards a more democratic view of inquiry in school science is an appealing one.

However, Rancière (1991) argues that neither equality nor democracy can be a quality of societies or states because democracy is not a normal or permanent situation. It is sporadic and something that only happens from time to time and in particular situations (Ranciere, 2007). In other words, it is not the typical way in which the police order exists. Democracy, as theorized by Rancière, cannot be a guiding principle of schooling for the same reason that universal teaching will not 'take' and be established in society (Rancière, 1991). Assumptions of inequality form the basis of social institutions such as the school systems, which are predicated upon ideas of the social order (police order). Teaching for emancipation and democracy is an expression of equality thereby making both inconsistent with schooling. Therefore, as Ruitenberg (2008) comments, since democracy is never in place, it must always *enter* into the scene of inequality. Thus, "the best that can be done at the institutional level of schools and school systems is not to seek to offer democratic education, but rather to leave a space where democracy may enter (Ruitenberg, 2008, para. 29). She further explains, "democracy, when it is enacted, does not enhance or ameliorate schooling but rather intervenes in it and refuses the inequality inaugurated by schooling" (Ruitenberg, 2008, para. 24). One way in which to do this is to *teach* so that democracy may enter.

As Ruitenberg (2008) notes, if democracy really matters, then those who have a voice in educational systems will also be challenged to see the structures preventing democracy from entering and equality from asserting itself. For example, in Rancière's *Nights of Labor* (1989), which is about the beginnings of social emancipation among French workers in the nineteenth century, emancipation meant breaking with the norm that determined the day as the time workers work, and night as the time they rest. The beginning of emancipation was the decision to make something more of their night; to write, read, think and discuss instead of sleeping. Emancipation first meant reframing their own existence, breaking with their workers' identity, their workers' culture, their worker's time and space (Blechman, Chari, & Hasan, 2005). As Rancière notes, emancipation is a process rather than a goal, a break in the present rather than an ideal put in the future (Blechman et al., 2005). In the case of this study and its intervention, I am seeking intellectual emancipation by embracing a more dynamic view of inquiry and breaking the norms of intellectual domination in the schooling context by making the decision to reframe the pedagogical paradigm in the science classroom. The next section continues to explore the concept of science inquiry from a less conventional perspective.

2.4.3 Reading as inquiry. In response to the apathy of students towards reading science textbooks, Fang (2006) discusses two approaches. As Fang explains, "one is to minimize (or even eliminate) texts from science instruction in favor of an inquiry-oriented, hands-on curriculum that focuses on experiments and observation. The other is to replace science textbooks with educational novels that present scientific information in a storybook format" (p. 515). With respect to these arguments one can argue that experimental and field based science is hands-on, however, the reality is that much of science is concerned with ideas, making it more conceptual and theoretical in nature (Phillips & Norris, 2009). Tenopir and King's (2004) study of scientists strongly supports this perspective. Their survey of scientists revealed that scientists actually read a great deal of the time, averaging 553 hours per year or 23% of total work time. Further, the award-winning and high achieving scientist read more than the average. The participants expressed that reading is a main source of creative stimulation. When the data included all forms of communication and included speaking and writing, the average increased to 58% of their total work devoted to communication.

Given this evidence, it is essential to represent the activity of science to students as not only "hands-on" but "minds-on", recognizing "minds-on" activity is mediated by the spoken and written language (Phillips & Norris, 2009). Furthermore, a meta-analyses (Shymansky, Kyle, & Alport, 1983; Willett, Yamashita, & Anderson, 1983; Wise & Okey, 1983) as early as three decades ago, indicated that hands-on activities in the absence of minds–on activities were not as effective as first assumed (as cited in Yore, Bisanz, & Hand, 2003). It could be further argued that reading and writing are not only a part of science but essential to its sustenance as a discipline. Teachers need to make this evident to students through their practice; the fact that scientific knowledge is dependent upon text, and the way to scientific knowledge is through access to those texts. Scientific discourse depends upon the discourse that has gone before. Science as we know it does not exist without the capacity for comprehension, interpretation, analysis and critique of text (Norris & Phillips, 2003). Collecting, recording and documenting data, engaging in the works and ideas of scientists from any location in the world, examining and reexamining ideas and connecting ideas to people from different points in time, are only possible with the expressive power of text. According to Hand, Alvermann, Gee, Norris, Phillips, Prain, and Yore (2003), reading of text is instrumental to engaging in the social practices of science especially when one considers the quantity and variety of information sources available in print and electronic forms. Therefore, science literacy should include interpretive strategies required to cope with science text and to evaluate the validity, certainty, and credibility of claims embedded in the text (Bisanz et al., 2002; Goldman & Wiley, 2002 as cited in Hand et al., 2003).

All science students including English language learners must have the opportunity to engage with text beyond decoding (sound symbol relationships), word recognition, and information location in texts. In contrast, reading should be conceived as using the same mental activities central to science in the principled interpretation of text (Phillips & Norris, 2009). Norris et al. (2008) note:

> [when scientists read] . . . they puzzle over the meaning of what other scientist have written: question their own and other scientists' interpretations of text, sometimes challenging and other times endorsing what is written; and they make choices about what to read, how closely and critically to read, and about what to seek in their selections. When writing, they ponder phrasing that will capture what will carry the level of exactness they intend; choose words carefully to distinguish between degrees of certainty they wish to express; and select genres to describe what they did to collect their data and to provide justification for their methods. (p. 770)

Scientists and science learners interpret text as they read. The complexity of interpreting a text can be seen in the processes of "taking into account all the relevant information; applying criteria for judging the adequacy of interpretations; and judging whether a proposed interpretation explains the text and is consistent with known facts, whether alternative interpretations are inconsistent with known facts, and whether the proposed interpretation is plausible" (Norris et al. 2008, p. 770). Therefore, when the reading is of science texts, reading is inquiry; the principled interpretation of text by a reader who infers meaning by integrating text information with relevant background knowledge (Norris et al., 2008; Phillips & Norris, 2009). Romance and Vitale (2011) contend that background knowledge is only made relevant when the reader forges inferential links between their background knowledge and the text. Comprehension requires students to

> . . . link relevant background knowledge to their construction of a coherent mental representation that reflects the intended meaning of the text . . . If learner background knowledge is highly organized around core concepts and concept relationships, there is a greater likelihood that the knowledge can be accessed for gaining new knowledge and understanding as well as serve as the basis for interpreting authentic experiences presented within science instruction. (p. 2)

Envisioned this way, Phillips and Norris (2009) make the case that reading involves many of the same mental activities that are central to science and comprise a large part of what is considered doing science.

2.4.4 Reading research in science. The interpretation of reading has constantly evolved since the 1980's from text-driven models where readers were viewed to take meaning from text, to reader-driven models, where readers were viewed to create meaning exclusively, to the current interactive reader and text models. Rivard and Yore (cited in Yore, Bisanz, & Hand, 2003) note:

> Readers must interactively process information by instantly switching back and forth between selective perceptions of text-based information and concurrent experience, on the one hand, and by comparing the information and experience with their personal world-view recollections in short-term memory, on the other. Readers construct understanding in short-term memory by extracting information from the text-based situation and concurrent experience – called bottom-up processing – by retrieving information from their long-term memory and deciding what should be considered in a specific context – called top-down processing – while monitoring, strategically planning, and regulating the global meaning-making process – metacognition. (p. 698)

Reading in science is studied from different perspectives. One domain of study has focused on the effect of teaching a single reading strategy, such as, recognizing text structure (Spiegel & Barufaldi, 1994 as cited in Fang & Wei, 2010) or using graphic organizers on students' comprehension and recall of the science content in the text (Griffin, Simmons, & Kameenui, 1991 as cited in Fang & Wei, 2010). Other researchers such as Romance and Vitale (1992), as well as Guthrie, Van Meter, Hancock, Alao, Anderson, and McCann, (1998) have looked at ways in which to infuse reading into science. For example, Romance and Vitale (1992) used an integrated model (Science IDEAS) with fourth grade students that included in-depth science instruction, reading, and language arts objectives in an integrated fashion for 2 hours per day. The science instruction included hands-on activities, explicit strategy lessons and extensive reading of science texts. They found that the students in the integrated model displayed significantly greater achievement in science and reading than compared to their peers. According to Romance and Vitale (2011), findings from research conducted using the Science IDEAS model repeatedly demonstrated that,

> . . . repeatedly demonstrated that replacing traditional reading/language arts time with in-depth science instruction within which reading comprehension and

writing are embedded consistently results in higher achievement outcomes in both reading comprehension and science on norm-reference tests. (p. 2)

In Guthrie, Van Meter, Hancock, Alao, Anderson, and McCann (1998) study, the researchers worked with third-and fifth grade students. They designed a year-long integration of reading and language arts and science instruction, which they called Concept-Oriented Reading Instruction (CORI). The CORI model included teaching students reading strategies such as activating background knowledge, questioning, searching for information, summarizing, and organizing graphically. The study found that students who received the intervention were more likely to learn and use strategies for gaining knowledge from multiple texts than the students in the traditional instruction program. The model also had an indirect effect on conceptual knowledge in that it increased students' ability to use a range of strategies. The students were, therefore, more adept at using the strategies to gain more conceptual knowledge than their counterparts without the intervention. Guthrie (Guthrie et al., 2004; Guthrie & Ozgundor, 2002 as cited in Romance & Vitale, 2011) continued work with upper elementary students looking at building students' background knowledge for learning in science as a way to enhance reading comprehension. Researchers like Romance & Vitale (2011) and others that they cite such as, (Armbrusteer & Osborn, 2001; Beane, 1995; Ellis, 2001; Hirsch, 1996, 2001; Palincsar & Magnusson, 2001; Pearson et al., 2010; Romance & Vitale, 2010; Schug & Cross, 1998; van den Broek, 2010; and Yore, 2000) have also conducted research that supports interventions in which science content is the basis for building background knowledge and thus a greater proficiency in the use of reading comprehension strategies.

These studies support the fact that combining reading and science is beneficial. However, criticism is aimed at some authors for placing too much emphasis on integrating science into the reading program, as opposed to integrating reading into the science classroom. For example, Norris et al. (2008) point out that there is not much reading of science text in class and not much science content in language arts based reading. This distinction carries different consequences within elementary, middle school, and secondary education. For example, in elementary school settings where one teacher provides different subject matter instruction to the same group of students throughout the school day, the effect may be more subtle than in a middle and high school where teachers specialize in teaching one or two subjects to different groups of students on a rotating basis.

Biancarosa and Snow (2004) as cited in Fang and Wei (2010) point out that it is these changes to school structure and the academic environment, that result in middle school students being more disengaged from reading and learning than elementary students. This makes the integration of reading into secondary science more challenging than elementary science, especially if reading is seen to compete with the hands-on activities of the already limited science class period. However, the work of researchers such as Fang and Wei (2010) addresses these concerns through their study of sixth-grade students. Six out of 10 classes received reading infusion consisting of two components: one reading strategy lesson for 15-20 minutes per week; and a home reading program that encouraged students to read and respond to one quality science trade book per week. The study highlighted the complexity of developing and implementing an integrated reading-science middle school curriculum. They found many factors that affected the extent of reading infusion in science. These included: finding time for reading instruction in a packed curriculum, developing science teachers' knowledge of and commitment to reading, providing easy access to quality science literature, motivating students to read it, and the coordination of lesson planning and delivery between science teachers and reading teachers. Despite these factors, the results indicated that the students who received the reading infusion improved their science literacy over time and outperformed their peers in the control group.

These studies illustrate that even though the implementation of an integrated reading-science program is a complex and multifaceted undertaking, it can yield improved science literacy over time. Therefore, any conception of science literacy should recognize the dependency of scientific knowledge on texts, the importance of accessing text for scientific knowledge, and the role of the science reader to interpret and reinterpret text (Hand et al., 2003). In the next section, I will explore different perspectives on science literacy and highlight the role of text in the concept.

2.5 Scientific Literacy

Although there has been a global promotion of scientific literacy in education reform agendas and policies, as a general concept it has had and continues to have a wide variety of meanings. For example, OECD Programme for International Student Assessment (PISA, 2009) defines scientific literacy as

> . . . an individual's scientific knowledge, and use of that knowledge, to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues; their understanding of the characteristic features of science as a form of human knowledge and enquiry; their awareness of how science and technology shape our material, intellectual and cultural environments; and their willingness to engage in science-related issues, and with the ideas of science, as a reflective citizens. (p. 137)

In the Canadian educational context, the Common Framework of Science Learning Outcomes, K to 12 was developed by the Council of Ministers of Education to assist provinces in developing a common science curriculum framework. It addresses the concept of science literacy through the development of core values that underscore the belief that all students have the right to opportunities that cultivate scientific literacy throughout their educational development. The framework defines science literacy as, "an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them" (Common Framework of Science Learning Outcomes, K to 12, 1997, p. 4). In outlining the goals of the science and technology program, the Ontario Curriculum, Grades 1-8: Science and Technology (2007), includes a quote that defines a scientifically and technologically literate person as "one who can read and understand common media reports about science and technology, critically evaluate the information presented, and confidently engage in discussions and decision-making activities that involve science and technology" (p. 3).

Scientific literacy has usually implied a broad and functional understanding of science for general education purposes rather than the preparation of students for careers in science and technology. The descriptions tend to focus on the public's knowledge of science for informed decision-making and effective living with respect to the natural world (DeBoer, 2000). For researchers such as Norris and Phillips (2003), this requires citizens to be literate in both the derived and fundamental senses of science literacy- the 'derived' sense encompassing the traditions of being knowledgeable about science concepts, understanding the nature of science, the big ideas of science, and the relevance of the interactions among science, technology, society, and environment; the 'fundamental' sense referring to the ability to speak, read, and write in and about science, thinking, ICT, and emotional dispositions. Hodson (1998) conceptualized three broad domains of learning in science which include:

> Learning science – acquiring and developing conceptual and theoretical knowledge; learning about science – developing an understanding of the nature and methods of science, an appreciation of its history and development, and an awareness of the complex interactions among science, technology, society, and environment; and doing science – engaging in and developing expertise in scientific inquiry and problem-solving. (p. 5)

With the recent emphasis on Society, Technology, Society, and the Environment (STSE) in school science curricula, science literacy may also be envisioned in terms of the following arguments: (i) the intrinsic value of science education [e.g., making sense of natural phenomena]; (ii) the citizenship argument [e.g., science knowledge and knowledge of scientists' work required for citizens to make informed decisions in a democracy]; and (iii) utilitarian arguments [e.g., preparing students for science careers] (Hodson, 2008).

However, Shamos (1995) a critic of science literacy argued the futility of its universal pursuit. For over a decade, Shamos (1995, 1988) has argued against the goal of science literacy as an unattainable and unnecessary myth. He argues that students acquire specialized facts and theories about the world that is inaccessible to their experiences and irrelevant to their lives. His position, based on American population studies, asserts that the elements of scientific literacy, being too wide ranging, cannot be achieved. As well, it is naive to believe that students can learn to think like scientists since science literacy as it relates to science content, is not necessary as most people can function well without it (DeBoer, 2000; Roth & Barton, 2004).

Kennepohl (2009), in his discussion of science literacy in Canada seems to support this line of argument. In referring to the Canadian study by Miller and Pardo (2000), which found that, despite the consistently high PISA results, fewer than 20 percent of the Canadian adults are regarded as scientifically literate. Kennepohl points out that, at this same time frame, 52 percent of adults (more than 15 years in age) possessed a high school diploma (Statistics Canada, 2001) and 29 percent held some post-secondary qualifications. In reality, Kennepohl argues, the science related social issues of relevance to students often have very little science associated with them or the science is at a level of complexity making rational, independent judgments impractical. Similarly, Yore, Bisanz and Hand (2003) points out that even career scientists cannot follow the primary literature in all scientific disciplines and that science covered in media reports is often quite different from the "uncontroversial, reliable, and established science presented in textbooks" (p.705). Instead, DeBoer (2000) points out that Shamos counters popular views by "de-emphasizing science knowledge in favor of technology in the curriculum, and . . . removes responsibility for decision-making regarding science-based issues from the general public in favor of science experts" (p.591).

In similar arguments, Fensham (2002) suggests that it is "time to change drivers for scientific literacy" abandoning the traditional ways of identifying science content knowledge for the school curriculum. In addition, Hodson (2006) points out that as our view of science changes, so does our view of science literacy. He contends that curriculum proposals for greater scientific literacy change with the social context and "are a product of their time and place: they do not easily cross national or cultural boundaries (Tippens, Nichols, & Bryan, 2000) and do not transfer comfortably from one era to another" (para. 8).

It is not my objective to debate the many diverse definitions or theoretical perspectives of scientific literacy. For the purposes of this work, it is more productive to anchor my position on the aspects of science literacy that transcends time and social context. According to Hodson (2006), these are the ones that liberate the mind as opposed to the elements that focus on the economy, jobs, or the production of technological goods. These would be the elements that include science literacy as a means to help people learn to think for themselves and to reach their own conclusions about a range of issues that have a scientific and/or technological dimension; the means to know what scientific resources to draw on as well as where to find them and how to use them; and to enable the populace to decide which experts to trust and which conclusions to rely on. Hodson (2006) comments:

> . . . that scientific literacy for active citizenship, responsible environmental behavior and social reconstruction lies more in learning about science than it does in learning science. No science curriculum can equip citizens with thorough first-hand knowledge of all the science underlying all important issues, but it can enable them to understand the significance of knowledge presented by others and it can enable them to evaluate the validity and reliability of that knowledge and to understand why scientists often disagree among themselves on major matters such as global warming, without taking it as evidence of bias or incompetence. It is not my intent to argue that knowledge of the major concepts, ideas and theories of science is unimportant; indeed, it would be a very curious state of affairs indeed to claim scientific literacy and admit to knowing no science at all. Nevertheless, my contention is that we should place considerably more emphasis on those elements of the history, philosophy and sociology of science that would enable students to leave school with a robust knowledge about the nature of scientific

> inquiry and theory building, an understanding of the role and status of scientific knowledge, an ability to understand and to use the language of science, some insight into the sociocultural, economic and political factors that impact the priorities and conduct of science, and some experience of conducting authentic scientific investigations. (para. 11)

This perspective of science literacy allows for more balance between the fundamental and derived senses of science literacy. It is quite clear that engaging in the ideas of the history, philosophy, and sociology of science would not be possible without the ability to read and write. As Hodson (2008) notes:

> At the very least, students need to be able to read, understand and evaluate scientific text in a wide variety of forms and styles (textbooks, teacher handouts, newspaper and magazine articles, press releases and news briefs, Internet postings and product labels, as well as graphs, diagrams, tables, chemical equations and mathematical representations), convert empirical data acquired in laboratory and fieldwork activities into text, and articulate and communicate their thoughts, ideas, beliefs and feelings in ways that are intelligible to the intended audience whether it be peers, parents, teachers or the wider public. (p. 2)

Yore et al. (2003) have highlighted that reading research from authors such as Korpan, Bisanz, Bisanz, and Henderson (1997), Norris and Phillips (1994), Phillips and Norris (1999) and Zimmerman et al. (2001) has also reflected this point of view with the study of scientific texts expanded from focusing only on student textbooks to studying how well people read and evaluate the research found in media reports. Yore et al. (2003), note that implicit in this broader study of scientific text is the recognition, based on widely advocated research (e.g., Goldman & Bisanz, 2002; Holliday et al., 1994; Koch & Eckstein, 1995; Mason & Boscolo, 2002 as cited in Yore et al. 2003) that to read, comprehend and evaluate diverse forms of scientific writing require abilities, strategies, and metacognition to be scientifically literate in the fundamental sense.

Unfortunately, a lack of exposure to reading in science at an elementary level, follows students into high school where junior and senior high school teachers act on the assumption that students are proficient in reading scientific texts (Peacock & Weedon, 2002). Norris et al. (2008) identified some studies where these areas of weakness lie. For example, they point to research by Norris and Phillips, 1994b; Phillips and Norris, 1999; Penney, Norris, Phillips, and Clark, 2003 that highlight areas of weakness in critical reading skills. Norris et al. (2008) found that students tend to attribute a "greater level of certainty to statements than was actually reported, to confuse causal and correlational statements, to confuse descriptions of phenomena with explanations of them, and fail to distinguish evidence from conclusions based on the evidence" (p. 769). Specifically, students performed well when the reading involved facts and observations for statements about the future. The students did not do as well with reading that required integrating and making connections with information from different parts of the text.

It is for this reason that the call from reading and writing researchers within the domain of science education to reconceptualize science literacy has been expressed over several years. That is to recognize the fundamental sense of literacy as reading and writing, as well as the derived sense of knowing science content. Science learners must understand the significant role of text in science as scientific knowledge is dependent upon text and knowledge is gained through its access. Science is advanced through cumulative discourse and given the variety of information sources available in traditional and electronic forms, science literacy must include the interpretive strategies needed to cope with the range of credibility and veracity associated with such texts (Hand et al., 2003). Therefore, in order to develop learners who are scientifically literate, science educators must also see themselves as literacy teachers.

2.6 Conclusion

After a review of the literature, it is clear that advancing a less conventional view of science inquiry in schools affords more emancipatory opportunities. Embracing a more progressive perspective of inquiry as an avenue for personal growth and development of the learner, in addition to acknowledging the importance of content and society, creates an environment that may be more amenable to democracy, equality, and the philosophy of universal teaching. This perspective supports the process of intellectual emancipation in students as they come to value the power of their own intelligence. Emphasizing the centrality of reading to the fundamental sense of science literacy and its role in inquiry, offers opportunities for intellectual emancipation to be fostered through the reading of science text as learners exercise their ability to learn for themselves. The literature speaks to the ways in which reading and writing are not only inextricably linked to the nature and fabric of science, but also to learning science. Without the expressive power of text and the development of comprehension, interpretation, analytical and critical thinking skills, science in its current form could not have progressed.

CHAPTER THREE

PERSPECTIVES ON ACTION RESEARCH

3.1 Chapter Overview

Through the exploration of action research in the relevant literature, this chapter provides a historical context and philosophical rationale for choosing action research as a method for this study. The chapter commences with discussion of selected historical origins of action research. Next, a partial comparison of the definitions found in the literature is discussed. A summary of types of action research follows and concludes with an overview of some of the influences of action research in science education.

3.2 Historical Origins of Action Research

Different authors contest the origins of action research. For example, authors such as Kemmis and McTaggert, (1982), Zuber-Skerrit (1992), and Holter and Schwartz-Barcott, (1993) assert that action research originated with the work of Lewin (1946). Lewin, a social-psychologist interested in improving the social organization of groups and communities is widely credited with coining the term "action research" in his paper titled "Action Research and Minority Problems". Others such as McKernan (1991), point to the works of Collier (1945), and Lippitt and Radke (1946) as evidence that action research was used prior to Lewin. Action research was a response to what some perceived as the traditional decontextualized methods of research that focuses on surveys and statistical techniques (Somekh & Zeichner, 2009). Somekh and Zeichner (2009) point out that as envisioned by Lewin, the purpose of action research was to "improve social formations by involving participants in a cyclical process of fact finding, planning, exploratory action, and evaluation" (p.7).

The historical and philosophical influences on action research are generally attributed to the following five movements outlined as discussed by McKernan (1996):

1. The Science in Education Movement;
2. The Experimentalist and Progressive Educational Ideology;

3. The Group Dynamics Movement;
4. The Post-War Reconstructionist Curriculum Development Movement; and
5. The Teacher-Researcher Movement.

During the nineteenth and early twentieth century, the Science in Education movement was characterized by the application of the scientific method to education. McKernan (1991) notes that this trend was represented in the works of Bain (1997), Boone (1904), and Buckingham (1926).

The experimentalist and progressive educational ideology era was notably marked by Dewey whose work was a significant influence on experimentalist and progressive educational ideology. Dewey "applied the inductive scientific method of problem solving as a logic for the solution of problems in such fields as aesthetics, philosophy, psychology and education" (McKernan 1991, p. 8).

In the nineteenth century, the Group Dynamics movement in social psychology and human relations training was used to address the social problems through qualitative social enquiry. For example, in the 1940s it was used to address problems such as the social problems associated with World War II, inter-group relations, racial prejudice, and social reconstruction. Noted researchers such as Lewin argued for action research as a form of experimental inquiry based upon the groups experiencing problems. He developed a view of research comprised of action cycles that included analysis, fact-finding, conceptualization, planning, implementation, and evaluation of action (McKernan, 1991).

In the 1950's and early 1960's action research was used in the study of industry and it developed a committed following in the USA at the Massachusetts Institute of Technology, and in the UK with Trist whose group at the Tavistock Institute engaged in applied social research (McKernan 1991; O'Brien, 2001). Wallace (1987), argues that "action research as promoted by the Tavistock approach paved the way for the 'external intervention' style of collaborative action research currently enjoying wide-spread usage; a style that highlights the concerns of the target group rather than the professional researchers" (McKernan, 1996, p.10).

In a review of the origins of action research, McKernan (1996) brings attention to early research such as Brady and Robinson (1952), Corey (1953), and Taba (1949) in the Post-war Reconstructionist Curriculum Development era. At the fore was Corey who believed "action research could significantly change and improve curriculum practice principally because practitioners would use the results of their own research investigations" (McKernan, 1996, p.10).

Interest in action research was high during the 1950s with this period being referred to as the era of 'cooperative' action research; named due to the cooperative nature between teachers and schools with outside researchers (McKernan 1996). However, by the end of the 1950's action research was in decline and under attack. Cochran-Smith and Lytle (1993), Sanford (1970), and Stenhouse, (1971, 1975) suggested that the split between science and practice and the shift towards the establishment of expert educational research and development laboratories was responsible. This resulted in the top-down development strategy of the research, development, and dissemination (RD&D) model, which separated theory and practice. The outcome segregated professional researchers from teachers, hindering the study of problems in the field (McKernan, 1991, 1996).

The Teacher-Researcher movement originated in the UK under the influence of Stenhouse (1971, 1975) and the Humanities Curriculum Project. It marked a radical departure from the conventional view of curriculum research as a specialist occupation (McKernan, 1996). Stenhouse (1975) advocated for teachers to study their own work, arguing "curriculum research and development ought to belong to the teacher" (p. 142). He also believed that research was the route to teacher emancipation and "researchers [should] justify themselves to practitioners, not practitioners to researchers" (Cochran-Smith & Lytle, 1993, p. 8). Themes from this movement extend as far back to "Dewey who argued that the only remedy for educational development's disposition to jump uncritically from one new technique to the next was teachers who had learned to be "adequately moved by their own ideas and intelligence " (Cochran-Smith & Lytle, 1993, p. 9). Dewey recognized the association "between teaching as democratic work and the teacher as researcher" and contended that "one of the most important roles of a teacher was to investigate pedagogical problems through inquiry" (Kincheloe, 2003, p. 38).

Contributions continued with Carr and Kemmis in 1986 who developed action research methodology by locating it within the framework of critical theory relationally to the work of Habermas. Other recent and significant teacher-researcher developments include the Classroom Action Research Network (CARN); the National Association for Race Relations Teaching and Action Research (NARTAR); and the First World Congress on Action Research (1990) in Australia (McKernan, 1996).

In more recent times Cochran-Smith and Lytle (1993) also recognized the importance of teacher research as they point out "research by teachers represents a distinctive way of knowing about teaching and learning that will alter—not just add to—what we know in the field . . . as it accumulates and is more widely disseminated, research by teachers will represent a radical challenge to our current assumptions about the relationship of theory and practice, schools and universities, and inquiry and reform" (p. 85). Teacher-research continues to develop as researchers such as Elliott (2007) expand theories of professional teacher knowledge, development, and learning through action research.

3.3 What is Action Research?

There are many definitions of action research in the literature. The following is a list of definitions from the literature on action research:

- It is a "systemic inquiry that is collective, collaborative, self-reflective, critical and undertaken by participant in the inquiry" (McCutcheon & Jung, 1990, p. 148)
- Defined as, "a form of collective self-reflective inquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out" (Kemmis & McTaggert, 1990, p. 5).
- "Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint

collaboration within a mutually acceptable ethical framework (Rapoport, 1970, p. 499).

- It is 'the study of a social situation with a view to improving the quality of action within it" (Elliott, 1981).
- A "systematic and sustained inquiry, planned and self-critical, which is subjected to public criticism and to empirical tests where these are appropriate" (Stenhouse, 1981, p.113).
- Rooted in critical-emancipatory terms, action research is simply a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out" (Carr & Kemmis, 1986, p. 162).

According to McKernan (1996) a minimal definition of action research would be as stated:

> Action research is the reflective process whereby in a given problem area, where one wishes to improve practice or personal understanding, inquiry is carried out by the practitioner – first, to clearly define the problem; secondly, to specify a plan of action- including the testing of hypotheses by application of action to the problem. Evaluation is then undertaken to monitor and establish the effectiveness of the action taken. Finally, participants reflect upon, explain, develop, and communicate these results to the community of action researchers. Action research is systematic self-reflective scientific inquiry by practitioners to improve practice (p. 5).

The principles of empowerment of participants, collaboration through participation, acquisition of knowledge, and social change are seemingly found within all definitions of action research. These are usually achieved through a spiral of action research cycles, which include planning, acting, observing and reflecting (see argument in Masters, 1995). There are multiple models of the action research spiral. For example, Kemmis and McTaggart (1982) represent a series of cycles with each cycle consisting of four steps: planning, acting, observing, and reflecting. In contrast, O'Brien (2001) describes a model by Susman (1983) as having each cycle of action research consisting of five phases: identifying or defining a problem, considering alternative courses of action, selecting a course of action, studying the consequences of an action, and identifying general findings. A model by Kemmis and McTaggart (1998) is widely used and consists of the cycles represented in the following model (Figure1).

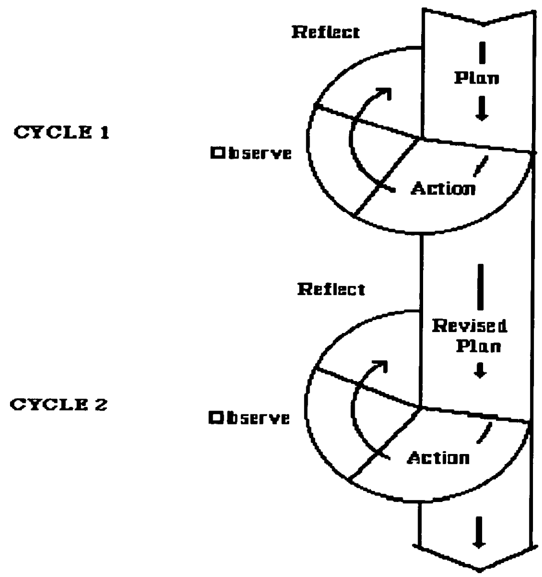


Figure 1. **Action Research model by Kemmis and McTaggart (1998).**

According to O'Brien (2001), the emphasis on participants as researchers, the belief that people are more apt to apply what they learn when they undertake their own action, the application of research in real-world situations to real world problems, and the open acknowledgement of "bias" from the researchers are qualities that separate action research from other types of research.

3.4 Types of Action Research

In this section, I will discuss four types of action research. There are three popular groupings or classifications of action research discussed in the literature. They are represented in Table 2:

Table 1
Classifications of Action Research

Researcher	**Classification**	**Type of Action Research**		
Grundy (1988)	Modes of Action Research	Technical	Practical	Emancipatory
Holter & Schwartz-Barcott (1993)	Types of Action Research	Technical Collaborative Approach	Mutual Collaborative Approach	Enhancement Approach
McKernan (1991)	Types of Action Research	Scientific-Technical View of Problem Solving	Practical-Deliberative Action Research	Critical-Emancipatory Action Research
McCutcheon & Jung (1990)	Perspectives of Action Research	Positivist	Interpretivist	Critical Science

Masters (1995) captured the themes of these classifications in the following designations discussed below:

- **TYPE 1: Technical/Technical-Collaborative/Scientific-Technical/Positivist**
- **TYPE 2: Mutual-Collaborative/Practical-Deliberative-Interpretivist Perspective**
- **TYPE 3: Enhancement approach/Critical-Emancipatory Action research/Critical Science perspective**

3.4.1 Technical/technical-collaborative/scientific-technical/positivist. In this approach, a specific person or group usually initiates the project. Their experience or qualifications set them apart as subject matter experts or figures of authority on specific issues (McKernan, 1996). The underlying goal of the researcher in the technical approach is to test a particular intervention based on a pre-specified theoretical framework. The researcher identifies the problem and a specific intervention. The researcher solicits the involvement of the practitioner to facilitate with the implementation of the intervention. The collaboration between the researcher and participants is technical and based on facilitation. Technical action research promotes more efficient and effective practice. It promotes personal participation by practitioners in the process of improvement. The power in technical action research is situated within the facilitator since it is they who have the 'idea', which is the source of power for action (Masters, 1995).

3.4.2 Mutual-collaborative/practical-deliberative-interpretivist perspective. McKernan (1991) comments "[t]he goal of practical action researchers is understanding practice and solving immediate problems" (p. 20). Researchers gain a new understanding of their practice and the implemented changes tend to have a more lasting effect. In this approach, the researcher and practitioners come together as a team to identify the problem, the underlying causes, and possible interventions to resolve the problems (Masters, 1995). The problem is defined after negotiations between the researcher and practitioner whereby a mutual understanding of the problem and the solution is reached.

In practical action research power is shared between a group of equal participants, but the emphasis is upon individual power for action (Grundy, 1982). The power in practical action research is shared between individuals who are equal within the group. However, the emphasis is on the individual power for action.

3.4.3 Enhancement approach/critical-emancipatory action research/critical science perspective. This approach to action research was heavily influenced by the work of Habermas (1981) and promotes "praxis in the participating practitioners. According to Holter and Schwartz-Barcott (1993, p, 302) there are two main objectives to this type of action research:

- To increase the closeness between the actual problems encountered by practitioners in a specific setting and the theory used to explain and resolve the problem.
- To assist practitioners in identifying and making explicit fundamental problems by raising their collective consciousness.

The critical social theorist Habermas (1972) presents a theoretical model for understanding emancipatory action research. Habermas (1972) states, "It is through the development of critique that the mediation of theory and practice is possible. The development of action-orientated critique has three phases: theory, enlightenment, and action" (as cited in Grundy, 1982, p. 358). These three phases are outlined as follows:

Theory. Critical intent is the motivating force that drives action and interaction throughout all stages of emancipatory action research. It is especially important in the development of the theoretical perspectives, which informs and underpins a project. Grundy (1992, p. 358) defines critical intent as not being "the intention to be rigorously discriminating only with regard to one's own practice. It has a social consciousness as well in that it is a disposition toward the critical assessment of the extent to which the social milieu impedes the fostering of the good". Emancipatory action research is informed by theory in that it is the confrontation with the theory that spurs a researcher to undertake the practice (Grundy, 1982).

Enlightenment. The reflection process within the group allows critical theorems to be applied and tested. From the process of group reflection come authentic insights or enlightenment (Habermas 1972 as cited in Grundy 1982). The focus of this phase is on the past.

Action. Strategic action is an outcome of the enlightenment phase and is a form of praxis. The focus of this phase is on the future. The power dynamic in this type of research is characterized by the power residing within the group and not the facilitator or individual in the group. It is often a change of power relationships within the group that causes a shift from one mode to another (Grundy, 1982).

3.4.4. Participatory action research. Participatory action research (PAR) embraces the principles of participation, reflection, empowerment, and emancipation of groups seeking to improve their social situation (Holter & Schwartz-Barcott, 1993). The focus is social and community oriented as opposed to classroom and school issues, with an emphasis on research that contributes to emancipation or change in our society. Creswell (2002), drawing on the works of Freire, Habermas, Kemmis and Stringer note that this approach has emerged as an action-oriented, advocacy means of inquiry. Further, Creswell (2002) highlights the different but compatible names by which various authors refer to this type of action research. For example, ""community-based" inquiry (Stringer, 1999, p.9), "collaborative action research" or participatory research (Kemmis & McTaggart, 2000, p. 567), or "critical" action research" (as cited in Mills, 2000, p. 7). Participatory action research can thus be seen as a "collective, self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social practice" (Kemmis & McTaggart, 1990, p. 5).

3.5 Action Research in Science Education

Action research has become closely associated with three domains of science education: teacher education and professional development; research on science learning; and curriculum development and implementation. In all cases, teachers are in the role of researcher, either studying their own methods of instruction and assessment; examining the cognitive processes of learning; or participating in the process of curriculum research and development. Many early research initiatives paved the way for the continued development and use of action research in the science education community. Abell and Lederman (2007) bring our attention to the work of authors such as, Minstrell (Minstrell, 1982, Minstrell, 1992, Feldman & Minstrell, 2000) who produced a body of work from studies in his high school physics classes. They note that the insights gained about student thinking and learning, along with efforts to design, implement and study teaching strategies aimed at improving student understanding of science content, greatly influenced the science education community. Abell and Lederman (2007) also highlight the research of Lampert and Ball (Ball, 1993; Lampert, 1990, 2001; Lampert & Ball, 1998) in elementary school mathematics teaching. Their work played a prominent role in revealing the potential contributions of subject-matter-focused teacher research. Abell and Lederman (2007) point to Lampert and Ball for inspiring teacher research doctoral dissertations in mathematics and science. Additionally, researchers such as Pedretti and Hodson (1995), and Hodson and Bencze (1998), aimed to transform the science curriculum by focusing on issues of science, technology, and society through collaborative action research groups with teachers. In addition, teachers of writing and other literacy skills have engaged in action research within science education. For example, Abell and Lederman (2007) cite Saul and Reardon's (1996) action research project in which elementary school teachers studied ways to integrate the teaching of reading and writing with science. More recently, science educators have been part of the action research community with teacher action research in the following areas.

3.5.1 Teacher education and professional development. Capobianco (2007) examined the experiences of science teachers who sought to better teach science for diverse groups of students. They aimed to change their practice by conducting action research on feminist science teaching. The study indicated that teachers gained new knowledge about feminist science teaching and pedagogical ideas for their practice.

In a project that has implications for teacher preparation programs, Buck, Mast, Ehlers, and Franklin (2005) studied the process of a novice teacher creating a classroom conducive to the needs of middle-level English language learners. The action research team consisted of a science educator, an English-language learner educator, a first-year science teacher, and a graduate assistant. The study revealed three significant outcomes. First, successful strategies a new teacher must utilize for teaching middle-level English language learners in a mainstream classroom involve complex structural considerations that are not part of the teacher's preparation; second, although learning increased for all students, there were differences in learning achievement between English language learners and non-English language learners; and third, student and peer feedback was an effective means of enhancing the growth of a new teacher seeking to increase their skills in teaching English language learners.

Lebak and Tinsley (2010) report on a model for integrating teacher action research within professional development initiatives. The authors incorporated the use of videos of teachers teaching along with collaboration opportunities for peers, students, and other sources to identify goals for improving their teaching practices, develop action plans, and analyze the results. The authors suggest that their action research process transformed the pedagogical approach of the teachers from text book driven to student centered inquiry approach.

3.5.2 Research on science learning. Zhang, Passalacqua, Lundeberg, Koehler, Eberhardt, Parker, Urban-Lurain, Zhang, and Paik (2010), report on an action research project conducted by a kindergarten teacher who collaborated, with a small group of colleagues, to investigate how to use "Science Talk" to promote student learning. A

Problem-Based Learning approach was adopted to guide the collaborative action research and based on the data, the researchers concluded that the teacher's action research improved student learning as well as led to her own professional growth.

A collaborative action research project by Goodnough (2010) examined the nature of science teacher learning. Participants adopted a 3-part teacher knowledge and learning framework: knowledge-for-practice, knowledge-in-practice, and knowledge-of-practice (Cochran-Smith & Lytle, 1999). Goodnough (2010) focused on the case study of a primary school teacher who desired to make her teaching practices more student-centered. The study highlights several themes such as the role of collaborative inquiry in supporting teacher learning, contextual issues and concerns that impact teachers' daily classroom practice, and the types of knowledge generated by teachers within collaborative inquiry communities.

3.5.3 Curriculum development and implementation. Action research studies have also influenced curriculum. Gough and Sharpley (2005) report on an Australian study of a group of primary school teachers and students from 27 schools who implemented new science teaching and learning strategies through an action research-based model of curriculum change in science. Their work led to more environmental education occurring in the schools' curriculum through re-positioning science education on the same plane as literacy and numeracy as a curriculum priority. This encouraged schools to develop initiatives around the support of environmental education.

A study on gender and science education conducted by Nyström (2007) focused on the development of more inclusive pedagogies for natural science classrooms. The study, conducted in two Swedish secondary schools, reported that the natural science discourses prevented some students from entering into the discursive arena of natural science. The article highlights how student voices draw on wider societal discourse when they talk about being natural science students at this time in history. The outcomes of the analysis highlighted the importance of teachers listening to students' voices and drawing on them when addressing issues of inquiry, equity, and school-based reform.

3.5.4 Addressing the critics. Capobianco and Feldman (2010) discuss how critics of action research view it as deficient in comparison to rigorous, empirically or "scientifically"- based research. They state, "Because results and conclusions drawn from action generally stress contextualized knowledge or learning situated within one's classroom practice, there seems to be an implicit consensus that they have little credibility due to a lack of generalizability, validity, and reliability" (p. 910). There are also debates as to what counts as valid research data, knowledge, evidence, and effectiveness. The question of who can be regarded as a "knower" of issues related to teaching, learning and teacher development are also raised thereby placing action research in the realm of "practitioners" rather than someone who deals with "scientific research" (Capobianco & Feldman, 2010). In addressing the call for quality action research, Capobianco and Feldman (2010) propose assessing research efforts and products under the umbrella of action research as a methodology. They state:

> By taking a methodological stance, we place the focus on teachers' orientation towards research, rather than a particular set of research methods. Emphasis, therefore, is placed on both the improvement of practice and the teachers' generation of new knowledge and understanding about the significance of their actions and responsibilities as teachers and researchers. (pp. 912-913)

They also advocate for advancing research on science learning, curriculum development, and school-university partnerships by positioning the research experience of teachers, graduate students, teacher educators, school administrators and curriculum specialists as central to the advancement of these efforts.

3.6 Summary

This chapter provided a summary of selected works of action research in education. The evolution of action research was discussed by outlining eminent authors who, through their research, were instrumental to action research development as a qualitative research method. The influence of action research in the domain of science education was also highlighted. This review of action research in the literature provides a foundation for justifying the adoption of this research design in my study. I further articulate my use of action research methodologies in the following chapter in which I discuss my research as a case study in an action research project.

CHAPTER FOUR

METHODOLOGY

4.1 Chapter Overview

This chapter outlines the methodology used in my study. The chapter starts with an overview of the qualitative tradition of case study. I discuss the context in which case study is utilized in my research and then defines my case as an action research project. I outline the research design and phases, instructional context, participants, data collection tools, and the method of data analysis. I conclude the chapter by addressing ethical considerations.

4.2 Case Study

My study might best be represented as an action research project. I observed and performed a teaching and learning intervention aimed at fostering an environment conducive for the process of intellectual emancipation in participants. The focus of this study is on the participants' behaviors and reflections exhibited during the teaching and learning intervention in the science classroom and also on my teaching practices and beliefs. I adopt a case study as my action research. Using a case study approach facilitates an in depth understanding of real-life phenomenon (Yin, 2009). The literature representing case study research over the past three decades has produced more than 25 different definitions of case study, each definition carrying its own emphasis and direction for research (VanWynsberghe & Khan, 2007). Some researchers such as Stake (1995) consider the "case" as an object of study, while others such as Merriam (1998) and Yin (2009) consider it a methodology or procedure of inquiry. According to Creswell (2002), "A case study is an in-depth exploration of a bounded system (e.g., an activity, event, process, or individuals) based on extensive data collection (Creswell, 1998). "Bounded" means that the case is separated out for research in terms of time, place, or some physical boundaries" (p.485). Below are several types of cases that qualitative researchers often study (Creswell, 2002, p.485):

- The "case" may be a single individual, several individuals separately or in a group, a program, events, or activities (e.g., a teacher, several teachers, or the implementation of a new math program).
- The "case" may represent a process consisting of a series of steps (e.g., a college curriculum process) that form a sequence of activities.
- A "case" may be selected for study because it is unusual and has merit in and of itself. When the case itself is of interest, it is called an intrinsic case. Alternatively, the focus of a qualitative study may be a specific issue, with a case (or cases) used to illustrate the issue. This type of case is called an instrumental case, because it serves the purpose of illuminating a particular issue. Case studies may also include multiple cases, called collective case study (Stake, 1995), in which multiple cases are described and compared to provide insight into an issue.
- The researcher seeks to develop an in-depth understanding of the case through collecting multiple forms of data. Providing this in-depth understanding requires studying only a few cases, because for each case examined, the researcher has less time to devote to exploring the depths of any one case.
- The researcher also locates the "case" or "cases" within their larger context, such as geographical, political, social, or economic settings.

Two key, but different approaches that guide case study methodology are proposed by Stake (1995) and Yin (2003). Both authors define and describe case study from different perspectives as presented in the following table (Table 3):

Table 2
Case Study Perspectives According to Yin and Stake

Author	Case Type	Description
Yin (2003, 2009)		
	Explanatory	Explain presumed causal links in real-life interventions that may be too complex for survey or experimental strategies.
	Descriptive	Describe an intervention and the real-life context in which it occurred (Yin, 2009). They require that the study begin with a descriptive theory. "Thus what is implied in this type of study is the formation of hypotheses of cause-effect relationships. Hence the descriptive theory must cover the depth and scope of the case under study" (Tellis, 1997).
	Exploratory	Used to explore those situations in which the intervention being evaluated has no clear, single set of outcomes.
	Multi-case	Explores differences within and between cases. The goal is to replicate findings across cases. Because comparisons will be drawn, it is imperative that the cases are chosen carefully so that the researcher can predict similar results across cases, or predict contrasting results based on a theory.
Stake (1995, 2005)		
	Intrinsic	Used to understand the particular aspects of one or more cases.
	Instrumental	Used to understand another case or another issue. It provides insight into an issue or helps to refine a theory. The case is of secondary interest; it plays a supportive role,facilitating understanding of something else.
	Collective	Collective case studies are used to draw thematically from several cases.

Yin (2009) identifies five key components of case study research design. The first is the question. The case study approach is best suited for "how" and "why" questions. The second, propositions are used to move the research in the right direction by directing the researcher's attention to items in the study that should be examined. In studies where there is a legitimate reason for not having any propositions (experiment, survey) a specific purpose should be stated with the criteria by which it will be judged successful. Unit(s) of analysis is the third component. A unit of analysis defines what the "case" is. Fourth, is the logic linking the data to the propositions; and fifth, the criteria for interpreting the findings.

Like action research, one concern with case studies has been their lack of perceived rigor due to some circumstances where researchers have not followed systematic procedures or allowed biased views to influence the direction of the findings and conclusions. However, Yin (2009) points out "bias can also enter into the conduct of experiments (see Rosenthal, 1966) and the use of other research methods, such as designing questionnaires for surveys (Sudman & Bradburn, 1982) or conducting historical research (Gottschalk, 1968)" (p.14). Scientific generalization is another common concern with critics who argue that one cannot generalize from a single case. Yin (2009) proposes that if we consider an experiment, "scientific facts are rarely based on a single experiment; they are usually based on a multiple set of experiments that have replicated the same phenomenon under different conditions" (p.15). He argues, "case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study, like the experiment does not represent a "sample", and in doing a case study, your goal will be to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalizations)" (p.15).

Four tests to establish the quality of any empirical social research are also relevant to case studies. For the first, *construct validity*, Yin (2009) suggests specific case study tactics such as using multiple sources of evidence, establishing a chain of evidence, and having key informants review draft case study reports. Significant operational events that constitute 'change' and defining change in terms of specific concepts is also beneficial to construct validity. For studies that have no causal situation, such as descriptive or exploratory, the second, *internal validity* is not applicable. It is applicable in explanatory case studies when a researcher is attempting to explain how and why one event led to another. If the conclusion is reached that there is a causal relationship between the two events without knowing of other factors that actually influenced events, then there is a threat to internal validity. It is for this reason Yin recommends pattern-matching, explanation building, addressing rival explanations and using logic models. For the third test, *external validity* can be addressed using theory in single-case studies and replication logic in multiple-case studies. For example, in a single case study, the researcher is attempting to generalize the set of results to a broader theory. In essence, the theory that led to the case study is the same theory that helps to identify other cases to which the results are generalizable. For the fourth test, using case study protocol and developing a case study database are specific suggestions for addressing *reliability* in case studies (Yin, 2009).

Drawing on the work of Stake (1995, 2005), VanWynsberghe and Khan (2007) proposed a contrasting view of case study. First, they take issue with the definitions of case study that refer to it as a method, strategy, research design, or methodology. They argue that defining a case study as a method implies that it is a "technique, procedure, or means for gathering evidence or collecting data" (p. 3). They contend that regardless of the type of case study, none require specific data collection procedures but instead use a collection of research methods such as interviews, participant observations, and document analysis, techniques that are employed to build or uncover the case. They argue that a research design is a plan of action consisting of steps for collecting, analyzing and interpreting data that guide researchers from the questions to the conclusions. According to the authors, case study does not offer such a prescriptive plan. Therefore, it is not a research design. Stake (2005) separated case study from methodology by stating, "Case study is not a methodological choice but a choice of what is to be studied" (p. 438).

Therefore, their definition of a case study is that it is "a transparadigmatic heuristic that enables the circumscription of the unit of analysis. The circumscription of the unit of analysis is accomplished by (a) providing detailed descriptions obtained from immersion in the context of the case, (b) bounding the case temporally and spatially, and (c) frequent engagement between the case itself and the unit of analysis" (p. 9). Stake (2005) focuses primarily on the specificity of cases and how their uniqueness contributes to further understanding. According to Stake (2005) "Case study has been too little honored as the intrinsic study of a valued particular, as it is in biography, institutional self-study, program evaluation, therapeutic practice, and many lines of work" (p. 448).

4.3 My Case Study as Action Research

In my research intervention, I take the position of those such as Stake (2000) and VanWysberghe and Khan (2007) who argue from the perspective of case study as an object. That is, not using case study as a methodological choice but as a choice of what is to be studied. In my study, the case is the science classroom consisting of all the participants (teacher, students). Studying the classroom as a case allows me to explore the dynamics of the classroom environment by converging the data gathered from a variety of sources in my action research. My inquiry is an Action Research based study that may best be described as *embracing* action research during the intervention and the experiment, and action research that leads to potentially new actions post-intervention. During the intervention, I cycled through the action research spiral with an emphasis on action. When the intervention concluded it afforded me the opportunity to pause and consider action from the perspective of the data that I collected. This approach reflects the day-to-day professional reality of teacher-research that is integrated into the real-world setting of school life as it was not possible to give the time or emotional energy during the intervention to reflect upon the data collected. Figure 2 illustrates a diagrammatic interpretation of the cycles in my action research.

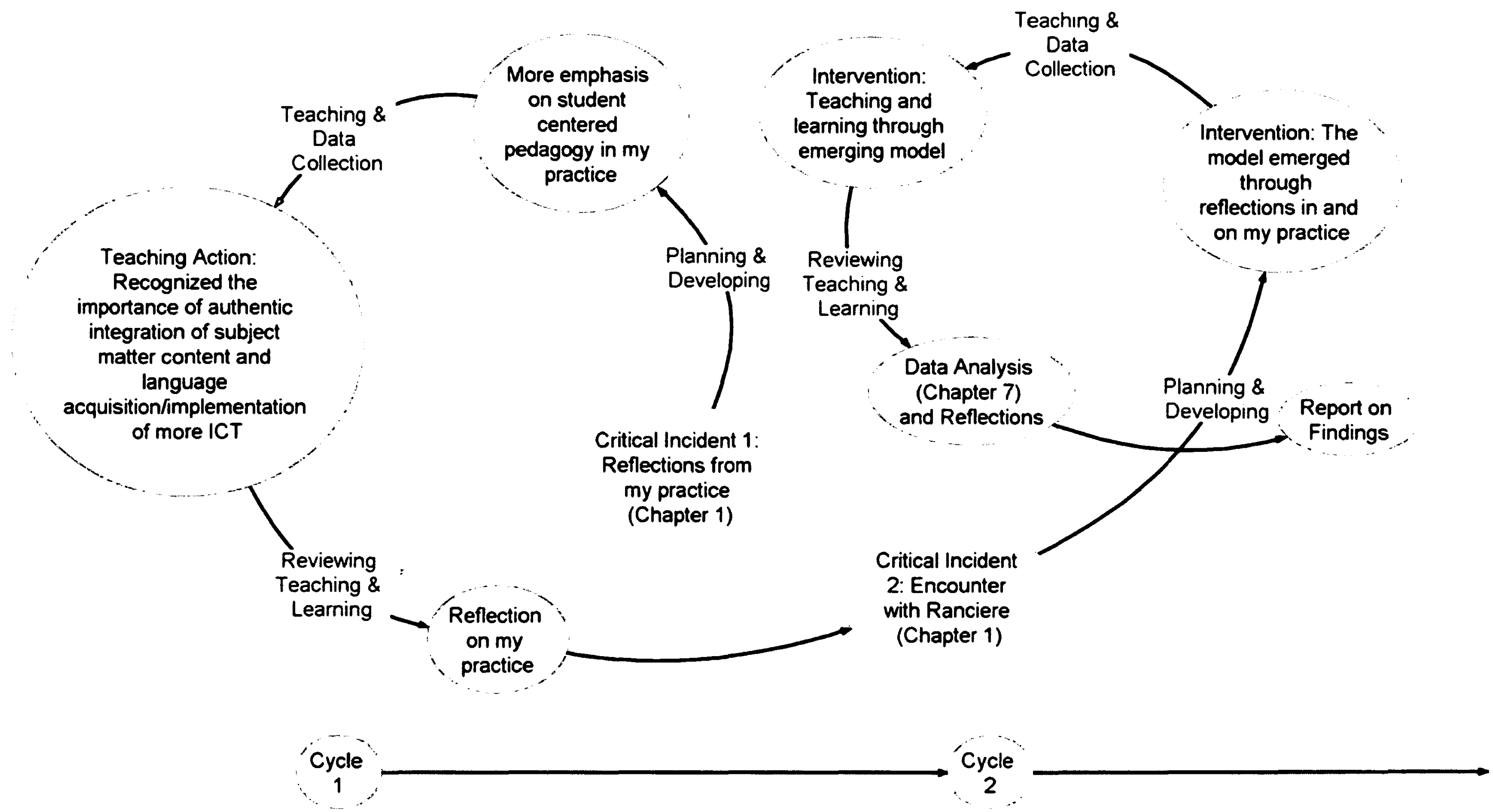


Figure 2. **Cycles of Action Research in my study.**

Action research methodology in science education is social research connected to an educational intervention. Historically, researchers who developed action research desired a social science that enhanced the capacities of the participants for self-determination and self-knowledge (Mithaug, 1996 as cited in Boog, 2003). Grundy (1987) argues "emancipatory action research seeks to develop in participants their understandings of illegitimate structural and interpersonal constraints that are preventing the exercise of their autonomy and freedom" (as cited in Cohen, Manion, & Morrison, 2007, p. 302). She postulates that participants move from unfreedom and constraints to freedom, autonomy, and social justice when they develop consciousness of the constraints.

My research focuses on the capacities of individuals during the implementation of a teaching and learning intervention at the classroom level. It is a study in the tradition of emancipatory action research in that it has as its goal the intellectual empowerment, autonomy and freedom of the student participants. However, the concept of social justice and social action within the emancipatory action research framework is interpreted non-traditionally based upon the philosophical underpinnings of the study. In the tradition of emancipatory action research, "emancipation was not only freeing oneself from domination but also transforming society and achieving a more equal distribution of power and control within society" (Boog, 2003, p. 428). The stance of this study is non-traditional, holding the view that emancipation can never be a social logic (Rancière, 1991). Rancière notes, "If explanation is a social method, the method by which inequality gets represented and reproduced, and if the institution is the place where this representation operates, it follows that intellectual emancipation is necessarily distinct from social and institutional logic" (Bingham & Biesta, 2010, p.9). From this perspective, societal transformation is recognizing that emancipation is for individuals and not institutions or societies. That is, "all emancipation can promise is to teach people to be equal in a society ruled by inequality and by the institutions that 'explain' such inequality" (Rancière in Bingham & Biesta, 2010, p.9). By making my research experience public, I aspire for the research to be relevant beyond my classroom with a broader agenda to challenge teachers of English language learners with an alternative way to think about the concepts of equality and emancipation within their science classrooms.

Boog (2003) cautions that a theoretical basis is not a guarantee of a positive end result for any type of action research. In addressing the question, "Which criteria does a model of action research have to fulfill if it is to realize its emancipatory content and effects?" (p. 434) he reminds action researchers that a project's success is dependent upon the interaction between researchers and participants, which forms the basis for the quality of the knowledge produced (Boog, 2003). In a review of research methods in education, Cohen, Manion, and Morrison (2007) refer to Kincheloe (2003) who suggests a seven-step process of emancipatory action research. Table 4 represents how these steps are reflected in my study.

Table 3
The Steps of Emancipatory Action Research in the Study

7 Steps of Emancipatory Action Research	Steps Reflected in My Research
1. **Constructing a system of meaning** ***Tentative system of meaning, a source of authority to which to look for philosophical guidance in considering the purpose for the research and teaching.***	- Construction of meaning based on theoretical perspective of Rancière' s definition of emancipation in the context of teaching and learning - From an action research perspective, system of meaning comes from an emancipatory framework defined in previous section. - Implement the heuristics of the research approach with a sincere emancipatory intention. (Boog, 2003)
2. **Understanding dominant research methods and their effects** ***Analyze assumptions of different research orientations and the knowledge base that emerges from them.***	- Literature review on qualitative methods with the aim to understand the assumptions of different research orientations and the knowledge base that emerges from them.
3. **Selecting what to study**	- Interest in English language learners and science education - Influenced by observations in practice - Influenced by philosophy of Rancière (1991) - Review of the relevant literature - Review other literature to provide support that it is of value to the field
4. **Acquiring a variety of research strategies**	- Literature review on qualitative methods- justifying choices based on the appropriateness to context and strength of data provided
5. **Making sense of information collected**	- Influenced by the system of meaning - Based on analysis of data collected
6. **Gaining awareness of the tacit theories and assumptions which guide practice**	- Literature review on action research outlined in the previous section. - Reflection-on-action (Schon, 1983) o Reflecting on the tacit understanding and assumptions I held to achieve a deeper understanding of student/teacher relationship, motivations and behavior with a view to the social outcomes.
7. **Viewing teaching as an emancipatory, praxis based act – praxis defined as action informed through reflection, and with emancipation as its goal**	- The whole research process shaped and continues to shape my views on teaching and learning.

4.4 Instructional Context and Participants

My research study was conducted in Ontario, Canada, an educational context where English and French are the only official languages of instruction in schools. In English-language schools, such as this research setting, French is studied as a subject.

The participating school was an elementary school (K-6) in a large urban setting. The school reflects the growing multilingual and ethnic diversity within the school board with an enrolment of 763 (see Schecter & Otoide, 2010). During the 2008/2009 school year, 43 different languages represented the linguistic makeup of the student population. The ten most prominent first languages of students are as follows: 24% Urdu, 20% English, 9.8 Tamil, 9.4 Arabic, 6.3 Gujarati, 5.6% Hindi, 2.9% Bengali, 2.3 Pashto, 1.8% Mandarin, and 1.3% Dari, Punjabi, Vietnamese, and Malayalam. The teaching faculty of 52 permanent staff is ethnically diverse with 9 teachers speaking one of the top ten first languages apart from English.

My research was a study of one term during the 2008/2009 academic school year. The data was collected in the second term, 2009 with the focus of study being *Understanding Earth and Space Systems* (Ontario Science Curriculum, 2007). The context was my class of 27 sixth grade students (ages 10-11). The class was designated "ESL (English as Second Language) rich" and, therefore, consisted of a mixture of English language learners (ELL) at various stages of English language acquisition (Figure 3 and Table 5) and non-English language learners. The class was one of three sixth grade classes, of which two are ESL rich classes (mixture of ELL and non ELL with a heavier emphasis on ELLs). Each ELL rich class had one part-time ELL teacher that worked with the classroom teacher to support the teaching and learning needs of the students. The study was conducted during my third year as a classroom teacher in an ELL rich class and my seventh year of teaching.

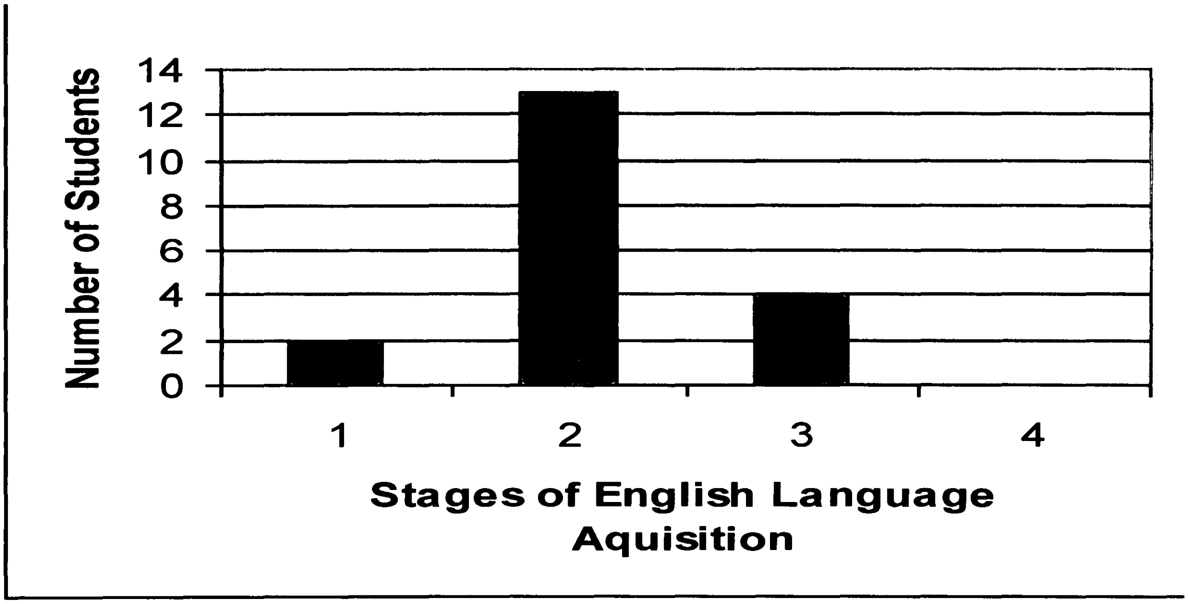


Figure 3. **Student stages of English language.**

Table 4

Descriptions of Skills at the Four Stages of Second-Language Acquisition and Literacy Development, ESL, Grades 4 to 6 – Reading(Supporting English Language Learners: A practical guide for Ontario educators, Grades 1 to 8)

Stage 1 students read and comprehend simple written English. They:	**Stage 2 Students read for specific purposes when background knowledge and vocabulary are familiar. They:**	**Stage 3 Students demonstrate increasing independence in a variety of reading tasks, with ongoing support. They:**	**Stage 4 Students demonstrate control of grade-appropriate reading tasks. They:**
- Recognize the English alphabet in both print and script - Begin to apply sight-recognition, phonetic, predictive, and contextual reading strategies - Recognize frequently used classroom vocabulary - Begin to acquire English vocabulary in all subject areas - Begin to identify the main ideas of simple passages with familiar vocabulary and supporting visual cues - Follow brief written instructions - Use learners' and bilingual dictionaries - Read simple sentences - Use alphabetical order - With assistance, use reading materials for enjoyment and modified school projects	- Use reading strategies to assist in determining meaning (e.g., predicting; deducing; inferring; rereading; phonics; recognition of cueing systems, repetition, and word families) - Understand short, simple phrases and sentences, instructions, and brief notes in a variety of print media with familiar vocabulary and context - Identify main ideas and key information in text - Begin to extract information, with assistance, from textbooks, resources, and dictionaries, using headings, margin notes, index, glossary, and graphic organizers - Begin to show some fluency in oral reading - Choose and read books, with assistance, for a variety of purposes, including personal enjoyment	- Skim and scan for key information in reading materials with familiar vocabulary and context - Summarize a story, identifying the main ideas and some details - Read and interpret text at a grade-appropriate level, with some visual support, using context and punctuation clues, phonics, and recognition of familiar vocabulary and word families - Choose appropriate materials for research purposes from a variety of sources - Read on a regular basis for personal enjoyment - Use academic vocabulary, including subject-specific language, with support - Use English and bilingual dictionaries - Find and use print and media resources, with some support	- Analyze unfamiliar text to figure out meaning - Identify elements of a story - Use vocabulary-acquisition strategies - Figure out unfamiliar vocabulary in a familiar context - Use skills in independent research to gather information (e.g., from library resources, community resources, print media, and computer resources) - Choose and enjoy material for personal reading similar in scope and difficulty to that being read by peers.

One of the primary teaching and learning pressures of the grade 6 year is preparation for the provincial EQAO (Education Quality and Accountability Office) test designed to provide information to parents, teachers, principals, and school boards on the achievement levels of students in the areas of reading, writing, and mathematics in the Ontario curriculum. The results are made public and schools are held accountable for performance scores. As a result, significant curriculum time is spent with a focus on preparing students to successfully respond to the test.

4.5 Data Collection Tools

The qualitative data was obtained by video observation of student/teacher conferences, video interviews, documents, and field notes of my practice.

Video observation of student/teacher conferences

Student/teacher conferences were digitally video recorded to document the learning context. Since I was an active participant in the study, particularly in the student/teacher conferences, I used digital video recording to keep a detailed record of what was said and what occurred. As a participant fully engaged in the experience, this was the most accurate and efficient way for me to observe interactions and discussions.

Video Interviews

The use of interviews as a data collection method begins with the assumption that the participants' perspectives are meaningful, knowable, and able to be made explicit. It is a means to gain insight into the thoughts, perceptions and feelings about the experience in the participants' own words. Detailed recording is a necessary component of interviews since it forms the basis for analyzing the data. Interview data is usually recorded and/or summarized in notes. Since I was an active participant in the interview process, I chose to digitally video tape the interviews as a means of data collection. The type of interview used for data collection in this study was unstructured or informal. Goodwin and Goodwin (1996) explain that, within the unstructured or informal interview category, there are variations with the 'naturalness' of the questions and question-asking behavior. The behavioral style can range from preparation of a general interview guide outlining the topics for questioning to ensure some uniformity from one interview to another, to interviews, which take the form of an informal conversation. In this study, I chose the former (see Appendix G) and conducted the interviews in environments (hallway outside of classroom, school seminar room) to which students were accustomed. Student interviews were videotaped at the end of the unit.

Documents: journal reflections/ questionnaire reflection/ journal work/ /research process rubric

The collection of personal documents is another source of data valuable in qualitative research. It requires collecting information from a variety of different sources. Lincoln and Guba (1985), as cited in Goodwin and Goodwin (1996) differentiate between documents and records: whereas documents are generally personal, records are prepared to attest to a formal event. In this study context, the focus is on personal documents (Fetterman, 1989), which can be described as first-person accounts of events and experiences. These could include items such as portfolios, photographs, artwork, and diary entries. In this study, the personal documents to which I refer are student reflections of learning in their science journals, artifacts of their work from the science journals, the Questionnaire Reflection sheet and the Research Process Rubric that they completed at the end of the study. The use of these documents is another form of direct student communication, which assists in triangulating the data and further helps to understand how they perceive their experiences. In addition, documents as a source for text data, provides the "advantage of being in the language and words of the participants who have usually given thoughtful attention to them" (Cresewell, 2002, p. 209).

Field Notes

Throughout the study my role as the teacher and researcher privileged me to an insider observational perspective. As I participated in the study I recorded reflections on what I observed and experienced. As Creswell (2002) notes it is difficult to take notes while participating in social interactions. Therefore, I waited until after classes to reflect and document events.

4.6 Data Analysis

My decision to draw on grounded theory for data analysis was based on the fact that, like action research, it has as its aim to understand the research situation. It seeks to find what theory accounts for the research situation as it is, as opposed to the testing of hypotheses. Grounded theory, a qualitative research approach developed by Glaser and Strauss in the 1960's is a methodology where theory/theories emerge from collected data. Glaser and Strauss (1967) outlined their procedures for grounded theory in their book, *The Discovery of Grounded Theory.* Their method was one of gathering data through systematic methodological procedures to develop theories from research that is grounded in the data.

In the 1990's Strauss, in collaboration with Corbin, theorized grounded theory methodology from an alternative perspective. Their work emphasized researchers predetermining categories for data and acknowledging problems with validity and reliability. Glaser (1992) criticized this approach arguing that they overly emphasized rules and procedures, a preconceived framework for categories, and theory verification rather than theory generation (Miller & Salkind, 2002). In the latest interpretation of grounded theory, Charmaz (2006) applied a more interpretivist approach to what is now known as the "constructivist" grounded theory model. Her aim was to make the grounded theory model more flexible in structure and to have more recognition for the meaning participants apply to events.

This history of grounded theory has produced three main research designs. The Systematic design (Strauss & Corbin, 1990, 1998) is characterized by the use of data analysis steps of open, axial, and selective coding which are used to develop categories from the collected data. These categories are then used to generate theory. In the first step of open coding, researchers identify several categories or themes found in the data.

Properties or subcategories are found within each category. The second step of axial coding links and organizes categories by relationship. The researcher then selects one open coding category, positions it at the center of the process or interaction being explored and then relates it to other categories. These other categories include the factors that influence the core phenomenon, actions taken in response to the core phenomenon, situational factors that influence the strategies, and outcomes from using the strategies. The use of diagrams at this stage is suggested by Strauss and Corbin (1998) to help illustrate the patterns that exist during axial coding, and helps focus the researcher toward theoretical explanations of the phenomenon under study. In the third step of selective coding, researchers write a theory about the interrelationship of the categories in the axial coding model (Miller & Salkind, 2002).

In the Emerging design (Glaser, 1992) the objective of a grounded theory study is for the researcher to explain a "basic social process". This explanation involves the constant comparative coding procedures of comparing incident to incident and incident to category, as well as category to category. In this model Glaser stresses the importance of letting theory emerge from the data rather than using specific preset categories (Glaser, 1992) such as seen in the axial coding paradigm. The focus is on connecting categories and emerging theory, not on simply describing categories. In the end, the research builds a theory and discusses the relationship among categories without specifying a diagram or pictures (Miller & Salkind, 2002).

Constructivist approach (Charmaz, 1990, 2000, 2006) focuses on the importance of meanings individuals attribute to the focus of the study. Applying active codes, the researcher looks at the participants' views, values, beliefs, feeling, assumptions, and ideologies of individuals and categorizes them during data collection. This approach is also known for researchers bringing some of their own views, beliefs, feelings and questions to the data.

The process of coding, as envisioned by Glaser and Strauss, was intended to develop grounded theories from research texts (as cited in Flick, 2006). However, my purpose in this study is not to generate a new grounded theory from the research data but to search for integrated themes. I applied abductive reasoning to the process in that I reasoned to the most likely explanation of events based on a set of observations that are incomplete (all possible observations are not known). I adopted an emerging design with a constant comparative analysis due to the nature of the qualitative data I collected. It was not initially apparent where to start due to the volume of data. Since I was analyzing my class as the case, I included all students in the analysis. I selected to start with the documents, specifically students' journal reflections, to identify codes to develop themes. Themes are similar codes aggregated together to form a major idea in the database (Creswell, 2002). Each student journal had several different reflection comments, each produced at different points and times throughout the learning cycle. As suggested with the constant comparison approach of an emerging design, I kept the texts of earlier students in mind while reviewing and coding other student's reflections. Therefore, I compared each student's reflections to others (reflection data set to reflection data set). Subsequently, for each student, I compared the data set of their reflections to the data sets of their Journal work, Questionnaire/Reflection, Research Process Rubric, and video to triangulate each student's own database to enhance the accuracy of the themes. Comparison was also conducted across students' databases.

It is interesting to note that Devetak, Glažar and Vogrinc (2010) also reported in their study of methodology of science education studies, that researchers used triangulation of qualitative data gathering methods in only 39.2% of the published qualitative or mixed research papers, and 60.8% of the papers used only one method to gather qualitative data.

With respect to the video observation of student/teacher conferences and the video interviews data, I went through a three-part process to determine appropriate segments. First, I viewed the video of student interviews and student/teacher conferences in their entirety to determine a sense of their content and context. Second, I described the video data by writing brief descriptive notes of the content. Third, the descriptive notes and video were reviewed to identify significant events that corroborated the themes.

I identified major and minor themes. I used a thematic analysis approach of layering themes by organizing the themes into layers from the basic to the more sophisticated (Creswell, 2002). I accomplished this by incorporating my minor themes within major themes, which then led to broader themes. I developed the themes to the point of saturation. That is, to the point where no new information added any further detail. As Creswell notes, the result is a complex analysis that works upward toward broader levels of generalizations.

I used four layers; **layer 1** consisted of data collected from student journal reflections. This layer was analyzed to develop general codes, which composed **layer 2**. These codes were labeled, '*comparing different texts*', '*credibility of authors and validity of information*', '*background experience*', '*monitoring understanding*', '*like/dislike of learning process*es, and '*motivation*'. **Layer three** was formed from these codes where I identified five minor themes: *self-motivation, self-efficacy, students' independent engagement with text, students' metacognitive reflections on learning,* and *students' conceptual understanding of science*. **Layer four** represents the combination of these minor themes into **two major themes** of *students' will to learn* and *how students learned science.*

4.7 Ethical Considerations

As in many action research studies in education, my study is embedded in the social world of my school within which it takes place, therefore, collecting data and analyzing through this research design will unavoidably impact the lives of students and colleagues. The extent to which others were influenced raises some criticism and ethical dilemmas subtly beyond the scope of the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS)* and particular to this research perspective. For example, I was a participant who had a key role in shaping the educational setting. Students were dependent upon me for their grades and quality of school life. This may have made it more difficult for them to decline participation in the study, especially when it is embedded as part of the regular schooling process. In addition to a participant's freedom to choose, critics also argue the extent to which participants can truly give informed consent when the nature of proposed changes are unknown in an emerging research design (Nolen & Vander Putten, 2007). The compromise to confidentiality is another ethical consideration since I could be associated with a particular class of students during the study. According to Waters-Adams (2006) "The justification for action research counters this criticism by suggesting that it is impossible to access practice without involving the practitioner. Practice is action informed by values and aims which are not fully accessible from the outside" (p. 25). However, to moderate some of these ethical issues, certain measures were employed. For example, parent consent forms (Appendix A) and student consent forms (Appendix B) were used to indicate that there was no penalty for refusing to participate and that student grades would not be affected (Nolen & Vander-Putten, 2007). Both documents were reviewed and approved by the Office of Research and Ethics, York University and ethics approval was granted for the study (Appendix C).

4.8. Summary

This chapter discussed my research as an action research case study. The rationale for the methodological design of the study was explained. The tools for data collection were outlined and the procedure for data analysis was illustrated. Chapter five will discuss the basis on which the pedagogical model was generated.

CHAPTER FIVE

PROPOSING A MODEL FOR EMANCIPATORY PEDAGOGY

5.1 Introduction

How did my practice respond to Rancière's notion of intellectual emancipation?

What model of practice emerged?

This chapter addresses this research question by outlining the pedagogical model that emerged through my action research case study. The model, inspired by Rancière's concepts of intellectual emancipation in *The Ignorant School Master*, explores the emancipatory possibilities afforded by inquiry through interactions with science texts. To return to Rancière for a moment in his exploration of intellectual emancipation, he contrasts how one's conceptions of the intellectual order among people and how one conceives the uses of intelligence determines the principle under which they operate; a principle of stultification or emancipation. This model strives to be emancipatory by breaking the patterns of what Rancière (1991) terms enforced stultification, which is present whenever one intelligence is subordinated to another. Presupposing the principle of equality, which Rancière argues, emancipates regardless of the procedure, book, or fact to which it is applied, the model obliges students to realize their capacity to learn by using their own intelligence as opposed to being the recipients of transmitted knowledge adapted to their perceived intellectual capacities. Additionally, in order to create a space more conducive to students' manifesting the equality of their intelligence, my model supports in principle:

1. The fact that all language is equal in status for learning and thinking and;
2. Equal access to text for English language learners and non English language learners. That is students freely choose their own text resources.

My action research study was conceived to take up Ruitenberg's (2008) challenge to not only recognize the structures and processes preventing democracy and equality from asserting itself in classrooms, but to offer a response with a model of emancipatory pedagogy within the context of my teaching practice. The three phases of the emergent model are discussed in the following sections.

5.2 Proposing a Model

This chapter proposes an action research pedagogical response to advancing the prospect of intellectual emancipation in students learning science. The model, as previously mentioned, evolved through an iterative, grounded process of action research set in my science classroom. The project was initiated based on the assumptions derived from the theoretical perspectives previously discussed in the first two chapters. Based on these priori assumptions, the model emerged through an iteration of reflections in and on my practice. The model is represented here in terms of three chronological phases, divided into discrete lessons. Figure 4 illustrates the phases of the model and the associated lessons. The figure also reflects the sources of data and the sequence of its collection throughout the model. The following sections (5.3, 5.4 & 5.5) provide an overview of these phases.

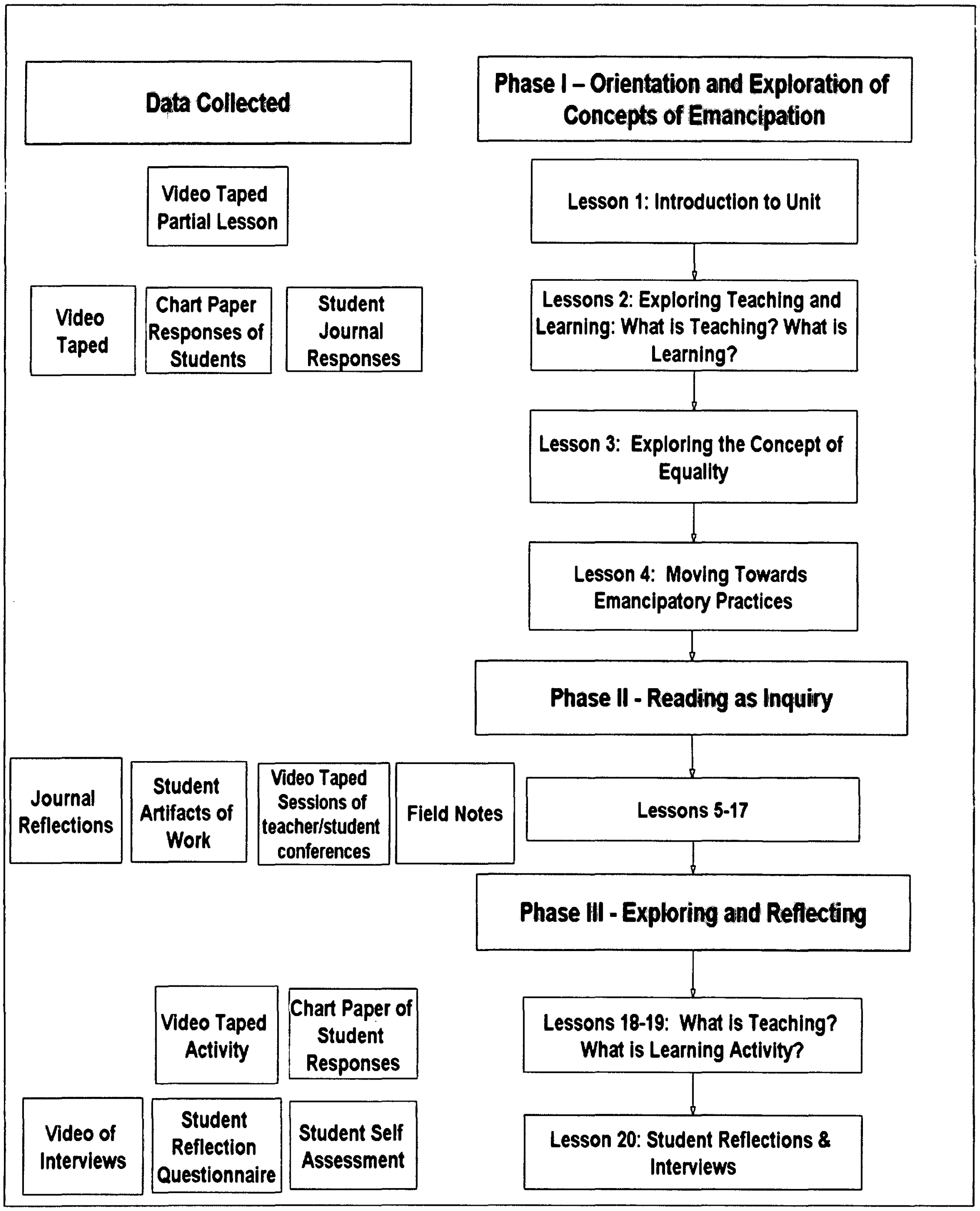


Figure 4. **Phases for the Emergent Model of Emancipatory Pedagogy.**

5.3 Phase I – Orientation and Exploration of Concepts of Emancipation

Phase I of the model, entitled '*Orientation and Exploration of Concepts of Emancipation,*' includes lessons 1 through 4 which consists of setting the context for initiating a different way of teaching, learning, and interacting in the science classroom. The phase offers an opportunity to facilitate discussions on teaching and learning and explore the concept of equality in the classroom.

I believed I had to set the context for this different way of being to successfully re-negotiate, with students, the pedagogical paradigm of the class and to make room for emancipatory practices. The first 3 lessons reflect this attempt.

Lesson 1 (80 min: 1 class) introduction to new science unit

The first lesson was a conceptual introduction to the new unit of study for term two. The unit of study, in this case, was *Understanding Earth and Space Systems* (Ontario Science Curriculum, 2007). The lesson offered a brief overview of the solar system and a class discussion recollecting what was learned and remembered from a class field trip to the Ontario Science Centre at the end of the first term where students watched an IMAX movie and participated in a workshop on Mars exploration. This lesson was partially videotaped.

Lessons 2 & 3 (160 min: 2 classes – 1 class AM, 1 class PM) exploring teaching and learning

The second class (AM) explores, from the students' perspective, the concept of teaching and learning. In the first part of the lesson, students participated in a large group discussion about learning. That is, from their perspective what constitutes learning? The students were asked to look and reflect on a collage of 24 numbered pictures displayed on a screen using an LCD projector (Appendix D). I then asked the following discussion questions:

1. In which pictures are people learning science? Why?
2. Which pictures have a teacher? Who is the teacher? Who is the learner?
3. When you look at all of the pictures, what do you think it means to learn?
4. When you look at all of the pictures, what do you think it means to teach?

A student volunteer recorded student responses on chart paper.

The second part of the lesson consisted of students distributing themselves into groups of 4 and participating in the following activity:

1. Choose three (3) pictures. What is the teaching/learning relationship between the people in the pictures? Who has control of the learning?
2. Which picture(s) show the best way to learn science? Why?

The lesson concluded with time for individual reflections based on the following questions:

1. In which situation can **you** learn the most?
2. Which learning situation is most comfortable for **you** (physical/emotional)?
3. Which learning situation do **you** like best? Why?

Students' responses were written in their science journal.

Lesson 3 (80min: 1 class) exploring the concept of equality

The third class (PM) continued the discussion on teaching and learning by introducing the students to Joseph Jacotot, the nineteenth century French teacher, whose insights form the basis for *The Ignorant School Master*. I explained his story in straightforward terms indicating that he was a university teacher who had to teach students whose language he did not know. I explained that because of this he discovered a different method to teach students, one that was based on believing in the equality of intelligence of all students. I explained to students that he believed students are to use their own intelligence. We discussed his definition of intelligence as the attention given to research (searching for what one needs to know) and the belief that we all have the ability to learn something. We discussed that the teacher's job is to keep students on track on the road to learning; that all people have the capacity to learn through their own intelligence, without a teacher's explanations; and the fact that what I know as a teacher does not need to affect what they know as students. We further discussed the idea that because of this equality they are equal to the authors and their texts; they are equal to the authors behind the text (book, website, article, etc.); You = Me = Each Other = Text. I also explained that equality meant that there is no hierarchy of language use between teacher and students. We discussed that all languages are equal in our learning environment and how a person's first language can be an excellent resource to their learning. Although the school board practices regarding the use of a first language (L1) for student learning is encouraged for the early stage of English language learning, I re-emphasized the point to ensure that all students regardless of their stage of English language acquisition understood that their L1 had equivalent status in this learning environment. In practical terms that meant supporting and/or encouraging: peer-to-peer discourse in students' first language; writing for learning in their first language (ex. journal writing, concept mapping, graphic organizers) if deemed an asset to student understanding; and parent/student support in their first language. This perspective is consistent with the research that shows encouraging students to develop their mother tongue does not impede the development of English academic skills (Schecter & Bayley 2002 as cited in Cummins & Schecter, 2003).

I explained to the students that for this term of science, together we are going to operate under this premise and learn a different way.

Lesson 4 (80 min: 1 class) moving towards emancipatory practices

In this lesson, we talked about how students would guide their own learning by choosing what they wanted to learn by formulating their own question(s) to answer. Students set up their science journals and we reviewed possible writing options for expressing what they learned. Students were not limited to the examples. These were merely suggestions.

In this lesson, I addressed the inevitable questions of "how will this be marked?" "How many questions do I need to answer to get a good mark?" I reiterated to students how learning science in this term would be different. As the learning was different, so would the assessment. I explained to students that this approach emphasizes verifying that they are *searching* as opposed to verifying *what* they have *found.* In other words, because the schooling structures dictate that students must be assessed for a mark, the focus of my assessment would be on their own individual effort of the search and their attentive study, not marking whether their answers are correct or comparing the volume of work between students. The students' science journals were to be their 'space' for learning and reflection, therefore, would not be marked. I would verify their search through what they shared in the student/teacher conferences throughout the unit of study.

5.4 Phase II - Reading as Inquiry

Phase II entitled, *'Intellectual Emancipation Through Reading as Inquiry with Science Texts'*, consists of lessons 5 through 17 which provide an opportunity for intellectual emancipation to be fostered and expressed through a pedagogy of inquiry with science texts. In this inquiry phase, intellectual emancipation is supported by three stages of interaction with text and reflects the emerging literature on reading *as* inquiry with science texts and science literacy.

The stages of interaction with text are represented in Figure 5.

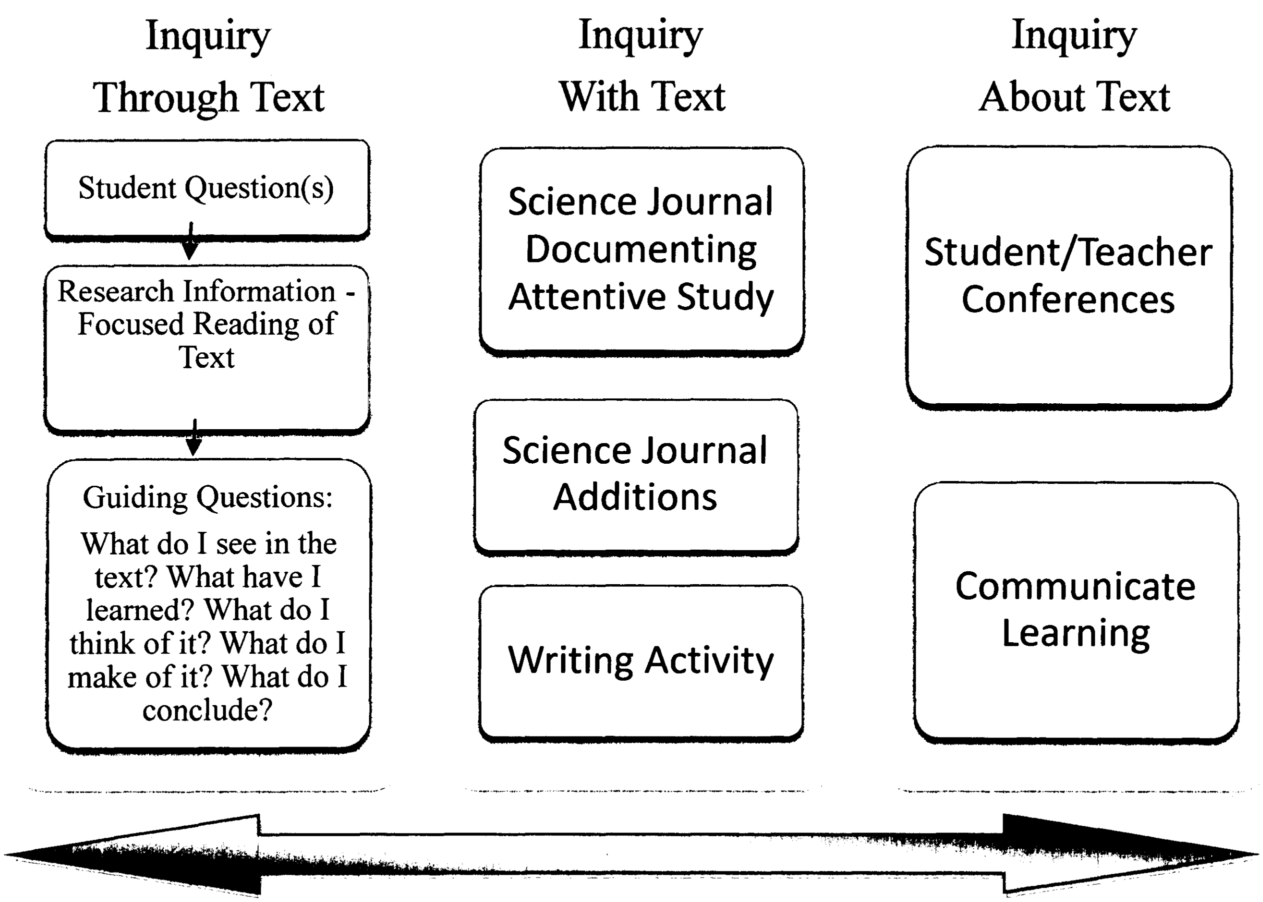


***Figure 5.* Reading as inquiry (iterative stages of interactions with text).**

As Godston, Day, Sundberg, and Dantzler (2010) note, many pedagogical practices provide significant scaffolding to guide student learning in inquiry-based teaching and involve times of direct instruction. However, these stages shift the focus from this type of pedagogical instruction to creating a learning environment that supports the development of inquiry skills through reading and the process of intellectual emancipation in students by compelling them to use their own intelligence to access their ability for inquiry, learning, and communication.

Although there is an overall logical sequence to students' progression through the stages, their learning journey is conceived as an iterative inquiry process involving dynamic movement through the stages. As a result, this pedagogy of inquiry with science texts supports a student's individual journey of learning where students are not formally led through each stage concurrently and may exercise the different options the stages afford.

The inquiry process of this phase of the model responds to researchers such as Norris and Phillips (2003), Wellington and Osborne (2001), and Yore et al. (2004), who argue for bridging the gap between literacy practices and the teaching and learning of science in school classrooms. The authors note that even as educators embrace inquiry as the cornerstone of school science, included in this goal should be the development of scientifically literate students through developing students' ability to access, comprehend, and produce science texts.

These stages represent the power of texts intersecting the domains of inquiry, reading, and science literacy. For Rancière, text is a vehicle for the process of intellectual emancipation; for the study of science, it is a vehicle for inquiry and the means through which the fundamental sense of science literacy is expressed. My text-based model of emancipatory pedagogy emphasizes the centrality of reading to the fundamental sense of science literacy and its role in inquiry. If one adopts the premise of Settlage (2007), "we should abandon efforts to teach *by* inquiry in favor of teaching *for* inquiry" (p. 204) in that inquiry is not a type of pedagogy but rather a skill set students develop, then reading *as* inquiry is one such skill.

Moreover, for English language learners the science text carries a dual function – to facilitate the learning of the English language and to enculturate students into the discourse of science. From a Rancière inspired perspective, the same way that Jacotot's students learned French in the Telemaque by using the intelligence they used to learn their mother tongue is the same way that English language learners learn English in science and the patterns of discourse in science by "observing and retaining, repeating and verifying, by relating what they were trying to know to what they already know, by doing and reflecting about what they had done" (Rancière, 1991, p. 10).

5.4.1 Inquiry through text. I am taking Inquiry through text to mean that, during the focused reading of science texts, students have opportunities to exercise their liberty by seeing and comparing things in the text for themselves in response to their guiding questions. As they address their questions through mastering a word, sentence, chapter or book, they gain knowledge of themselves as intelligence (Rancière, 1991).

In this stage students choose their own investigative questions within the topic of study. In this study, it was "Understanding Earth and Space Systems" of the Ontario grade 6 science curriculum. There is no added incentive for a greater quantity of questions posed. Instead, students moved through the stages based on when they determined they have answered the question. The focus is on the quality of their search, which is made evident by their responses to the reflection questions posed in the journal and similar reflection questions posed by the teacher through the student/teacher conferences.

The students choose their own information text from books, magazines, and electronic sources. The choice of text from multiple sources and media reflects the variety of text forms that today's learners' access. Provision of this choice is based upon the belief that a student has the intelligence to choose a text appropriate for their needs and reading level and the ability for self-correction if an unsuitable selection is chosen. English language learners, like all readers, apply the same strategies to monitor their comprehension, and to reflect on what they have learned after reading. The difference is reflected in the depth of understanding of the reading strategies and how they support learning as well as the complexity of reading material (Keene & Zimmermann, 1997; Pearson et al., 1992, as cited in Robb, 2003).

The primary goal of this inquiry stage is the focused reading of science text. Although there is no explicit teaching of reading strategies there is recognition and acknowledgement of the importance of such instruction. For example, research has shown that explicit instruction about text features, finding main ideas, summarizing text, accessing prior knowledge, using contextual clues, and monitoring understanding improved science reading comprehension (Spence, Yore & Williams, 1999 as cited in

Wang, Wang, Tai & Chen, 2010). This stage provides a framework in an authentic learning context for students to practice and advance their reading skills and strategies already attained to further their science understanding. It is only through many opportunities for purposeful interaction of science texts, do students have the opportunity to become independent in their understanding and use of science language.

5.4.2 Inquiry with text. In this phase of the model, Inquiry with text is taken to mean verifying learning by way of the text or in the words of the text and expressing that learning in written form. After the focused reading of science text(s) in stage 1, stage 2 provides the opportunity for students' learning and reflections on their learning to be recorded in their science journals. The inquiry stages are organized for students to go back to the search if they conclude after the student/teacher conference in stage 3 that the question is not adequately answered. Students have the opportunity for further examination the same text or read different texts and authors to further answer their question. New learning and reflections are added to their science journals.

As a way to document attentive study (not formal grading or assessment), and promote interaction with text, I designed and introduced the science journal as an organizational apparatus for students to track and organize their reflective processes as well as document what they learned. The structure of this double entry journal challenges students to ask the explicitly self reflective questions that Rancière deems necessary for the search, that is, to say "what he sees, what he thinks about it, what he makes of it" (Rancière, 1991, p. 20). Figure 6 shows the sample layout students were given as a guide for organizing their journal. The journal is also organized to highlight the author. The column with the question "What did I learn from the author?" is included to visually reinforce that there is a person behind the text, that the text represents the ideas of an individual to which they are equal. Additionally, the journal acts as a thinking tool by providing a student controlled space where they could write and think through reflection questions and interact with ideas in their own language. The journal is designed for students to respond to the reflection questions and record what they learned after each text (Figure 6).

Question:
Title of Text, Name of Book, Magazine, etc., Publication Date

Left Side of Journal *During Reading*		**Right Side of Journal** *After Reading Reflective Questions*	
What Did I Learn From The Author?	How Do I Know This? (Proof From Text)	1) What did you think when you finished the reading? 2) How did the ideas in the text relate to what you know about the topic or other things you have read? 3) What do you conclude?	1) What difficulties am I having? 2) How have I been successful in my learning? 3) Any comments about the learning process.

Figure 6. **Layout of student journals.**

The use of the journal as a reflection tool is supported by particular research in writing in elementary science literature (Hand, Hohenshell, & Prain, 2004; Shepardson & Britsch, 2001) which indicates that student's journal writing helps to connect new experiences of science phenomena and scientific explanations to familiar and personal perspectives. As Yore (1996) explains, reflection is a strategy closely aligned with the use of summarization. This strategy involves many critical skills such as, offering a reason for one's findings while considering the reasons suggested by others; seeking better reasons for believing something other than the norm or majority opinion; and questioning claims based on the source. Well-designed reflection strategies encourage writers to develop cross-referencing skills in order to make connections among ideas found in different information sources and subjects. Quality reflections reinforce critical thinking by requiring students to specify the criteria and thinking used to reach their judgment(s). Additionally, in a study of open inquiry teaching, Zion, Cohen, and Amir (2007) found that students who never experienced reflection as a process of their learning, found it difficult to see the stages of their work, keep a log and consider alternative evaluations.

Once students determine that they have satisfactorily answered their question, they communicate what they learned to others. In this study, it was through writing pieces although other forms of communication would also be appropriate. Students were provided with ideas and examples of possible writing formats to stimulate ideas. Students were not held to the examples as they could choose any written form of expression to present.

5.4.3 Inquiry about text. Inquiry about text is the social expression and development of the metacognitive processes and strategies used during reading. Whereas the other stages of inquiry in this phase tend to be more personal and private, the 'inquiry about text stage' engage students with their teacher and peers, through questioning, about their conclusions and the textual evidence from which it is drawn.

The third stage provides both teacher and students ongoing and active assessment of students' thinking, comprehension and ideas as they share their learning during the student/teacher conferences. The conference gives students the opportunity, through conversation, to make connections and process what they learned, determining the validity of information on their own.

The student/teacher conferences are an integral part of the stage. I conducted conferences while the other students were working in various stages. The goal is for each student to participate in the conferences several times throughout the cycle of stages. The conferences are designed to keep a student's will on track and committed to the search and monitor student comprehension of text, that is, their ability to interpret text in a coherent defendable manner. This is accomplished through learning conversations where students share what they are learning. The goal is to make the reflection questions the foundation for the conversations in an effort to not spoil the method by personally leading students through questioning or instructing them on what to do. This entails asking questions that help students clarify readings, justify conclusion, and monitor their own learning. The aim is for the reflection questions to keep the focus on the students' search as opposed to a teacher critique on the content they found and facilitate students' understanding and processing of text. A questioning approach is reflected in the literature across disciplines where teachers utilize questioning to promote memory, inquiry, stimulation of thinking, and in-depth processing of complex concepts (Feldman, 2003; McKeow & Beck, 2003 as cited in James & Carter, 2007)

Researchers stemming from Durkin's (1978/1979) seminal studies on questioning patterns have yielded extensive studies on the effectiveness of questioning on student comprehension. Several strategies to enhance students' comprehension of informational texts have been researched, as well as taxonomies such as Bloom's (1957), Barrett's (1968) and Taba (1975), which were developed to assist teachers in posing higher-level questions in response to texts (as cited in James & Carter, 2007). The student/teacher conferences use the taxonomy of questioning outlined by Rancière (1991) and parallels aspects of Beck and McKeown's (2006) *Questioning the Author* strategy that facilitates the building of understanding of text ideas through the use of questions and discussion. Similarities include: students are engaged in discussion in the course of reading; helping students independently construct meanings from texts and monitoring their understanding; actualizing the presence of the author to explore the message the author is conveying in the texts and to ask questions of the author when the text does not make sense; the responsibility of the student to construct meaning from text, and the responsibility of the teacher to probe students' thinking using questioning.

The learning environment encourages a social context that empowers students to be actively engaged in their learning by being comfortable asking questions, responding to questions, and open to communicate their ideas. In this stage students communicate what they learned by sharing their writing pieces either one on one in the student/teacher conference or with the class and members of the larger community. The feedback received through discussion and conversation helps to clarify, reinforce, or moderate the original conceptions. This feedback helps students form new ideas or support and reflect on an original idea.

In essence, throughout phase II, I aimed to be the cause of student learning by: 1) assuming that the students were capable to choose from a variety of texts, one from which they could learn and understand; 2) encouraging them to use the same intelligence they had used for learning a variety of other things without explications; 3) encouraging them through questioning, generally and specifically through conferencing, to pay close attention to the text, comparing and verifying; and 4) keeping them on track by linking my will to theirs in the enterprise of learning.

5.5 Phase III - Exploring and Reflecting

The third phase entitled, *'Exploring and Reflecting,'* has as its main focus opportunities for students to reflect on their learning experiences throughout the model.

Lesson s 18 & 19 (160 min: 2 classes) exploring teaching and learning

The class revisited the concept of teaching and learning discussed in lessons 2 & 3. Students worked in the same groups to reflect on the same images and respond to a question that asked them to identify any changes in their perceptions of teaching and learning. Students were invited to share their thoughts with the class. In addition, students filled out a Science Portfolio Reflection Questionnaire, and Research Process Rubric (Appendix F and G).

Lesson 20 student reflections and interviews

In this lesson students had an opportunity to reflect on their learning and articulate their experiences. With the support of another teacher who took my teaching duties, I was able to take a day to interview students in order to document their learning experiences over the term. These interview sessions were videotaped. In addition, students completed their Science Portfolio Reflection Questionnaire and Research Process Rubric as additional tools for reflection.

CHAPTER SIX
THE MODEL OF EMANCIPATORY PEDAGOGY IN PRACTICE

6.1 Introduction

Chapter 6 is a descriptive chapter outlining the model of pedagogy that emerged and introduced in Chapter 5. This chapter continues to addresses the first research question:

How did my practice respond to Rancière's notion of intellectual emancipation?

What model of practice emerged?

My goal is to offer the reader an introduction to the 'educational experiment' and present some early reflections on what occurred by providing details in practice. Chapter 7 explores the experiment through a more detailed analysis of the data collected.

This chapter is comprised of three sections. The first section describes the phase named, *Orientation and Exploration of Concepts of Emancipation.* In this first phase, the teaching sequence was introduced, and the concepts of teaching, learning, and equality were explored. The second section highlights phase two named, *Reading as Inquiry.* The stages of inquiry with science texts are described. The third phase named, *Exploring and Reflecting,* describes the opportunities students had to reflect on their learning experiences throughout the action research study and the process of revisiting the concept of teaching and learning discussed at the beginning of the intervention.

6.2 Phase I – Orientation and Exploration of Concepts of Emancipation

A necessary requirement for translating the theoretical vision of the model into a practical reality was to set the context for a different way of teaching and learning by re-negotiating with students, the teaching and learning paradigm of the class, which was a move towards more emancipatory practices. The move required the class and me to reconceive the intellectual order of the classroom which first meant to reframe the student/teacher relationship, identity, and ways of doing in the science classroom. As science learners, intellectual emancipation meant *accepting* to work within a student/teacher relationship that was different from what originally existed and was known. The shift towards emancipatory practices required me to think differently and act outside the norms of traditional teaching and learning. That is, to start from the presumption of 'equality of intelligence' by expressing my confidence in students' ability to inquire independently. Students were required to assume more responsibility for their learning than previously experienced.

Reorienting the class to a different way of learning was necessary to collectively engage students. In phase one, the pedagogical steps were:

1. Introduction to the Science Unit
2. Exploring Teaching and Learning
3. Exploring the Concept of Equality
4. Moving Towards Emancipatory Practices

6.2.1 Introduction to science unit. The first step to set the context was to introduce the new topic of study for the term, *Understanding Earth and Space Systems.* I facilitated a class discussion recollecting what was learned and remembered from a class field trip at the end of the first term to the Ontario Science Centre where students watched an IMAX movie and participated in a demonstration workshop on Mars exploration.

6.2.2 Exploring teaching and learning. In an attempt to re-negotiate the pedagogical paradigm for teaching and learning in the science classroom, we explored, from the students' perspective, teaching and learning as students participated in a large group discussion about learning. Pictures and questions were used to prompt critical conversation among students (Appendix D). I selected an array of pictures from free online images that could represent teaching and learning from different perspectives in order to challenge possible assumptions and stereotypes regarding teaching and learning. Students reflected upon the collage of 24 numbered pictures displayed on a screen using an LCD projector (Appendix D). The pictures were not necessarily related to science learning contexts. The large number of 24 enabled me to include a range of settings and activities that could be considered as conventional and non-conventional learning settings. Some pictures included images of children reading, others in hands-on activities. Pictures were also selected to represent different possible power relationships between the people in the images. The intent was to challenge students' thinking about teaching and learning thereby eliciting engaging conversations. After a time of reflection, I facilitated a whole class discussion centered on the following questions:

- In which pictures are people learning science? Why?
- Which pictures have a teacher? Who is the teacher? Who is the learner?
- When you look at all of the pictures, what do you think it means to learn?
- When you look at all of the pictures, what do you think it means to teach?

A student volunteer recorded the main responses on chart paper at the front of the class. Table 6 shows the responses that the student volunteer was able to record during the course of the discussion. Question 1 was asked to draw out students' views on science learning specifically, the questions: Does learning science look a particular way? Do certain requirements need to be met in order for science learning to occur? Question 2 was included for students to reflect on their image of a learner and that of a teacher – who is a learner and who is a teacher? Question 3 was asked to stimulate thinking around what it means to learn. For example, does learning only take place in certain environments? The last question similar to question 3 was meant to focus on what it means to teach. That is, is teaching expressed in a certain way?

Table 5
Student Responses to Whole Class Discussion Questions

Question 1 In which pictures are people learning science? Why?	Question 2 Which pictures have a teacher? Who is the teacher? Who is the learner?	Question 3 When you look at all of the pictures, what do you think it means to learn?	Question 4 When you look at all of the pictures, what do you think it means to teach?
Ellis: Picture 19 because their doing experiments	Ellis: Picture 24, 17, 11, 2 – because usually teachers teach kids and they're teaching. Helping and showing what to do- teaching them	Ellis: the reading (picture 18), writing (picture 18) and experiments (picture 21)	Ekjot: To tell or show people new things
Jason: Picture 16 because they are examining	Jason: Picture 11, 23, 24,20, 17 – because in all you can see one person taking lead of everyone else	Joshua: Leaning is observing or examining for notes. So you can study it.	Fatima: Teaching is discovering new things
Nathan: All the pictures because science has to do with everything	Darren: Picture 20 – people that are tall are adults/teachers. The adult is the teacher while the child is the learner.	Sushmitha: Learning is everything, whatever we love, see, or do. At least in 1 day we learn something	Audrey: Helping each other learn new things
Navneet: Picture 10 because looking at clouds to study them (reminds me of grade 5 when learning weather)	Riddhi: Pictures 2,4,6,11,14,12,17,20,24 because in all pictures there is an adult and younger people doing the same thing as the adult.	Navneet: Learning is something new you find out. Everyday you learn something new	Noura: You learn something and then sharing it with the world
Muhammad: All pictures because science has to do with everything and all these pictures represent it. science doesn't have to be about instruments	Muhammad: All pictures all pictures have something teaching them as in nature and a learner who can be learning from text as well		Muhammad: Through all forms. Reading, environment, science, etc.
Hashim: Picture 16 because they are watching eggs hatch	Samrin: Picture 11 – man is the teacher. The kids are the learners		Hashim: You have to learn something yourself to teach others

In response to question 1, Ellis and Jason's responses reflect an association with the processes (skills) of science whereas Nathan and Muhammad reflect a more encompassing view of science learning with Muhammad specifically mentioning that instruments are not necessary for science learning. Navneet and Hashim's responses reflect an association with previous science learning experiences. In question 2, of the students in the class who were recorded, most responses reflect the relationship they associate with the role of teacher and that of the learner. For instance, Ellis, Darren, Riddhi, and Samrin comment on the adult/child relationship to teaching and learning, whereas Jason comments on the activity of leadership in determining who is teaching and who is learning. Muhammad's comments indicate a more holistic view that considers the teaching possibilities of objects and other living things in addition to people. In response to question 3 Ellis and Joshua express the conventional aspects of learning, which include reading, writing, observing, experimenting and studying from notes. Sushmitha and Navneet, on the other hand, views learning in broader terms, citing learning in our everyday life experiences. For the last question, students' reflections on what it means to teach can be grouped in the following themes: teaching as sharing with other people or the world at large, the collaborative aspect of teaching by helping each other learn new things, and discovering or learning new things in order to teach others.

From the large group discussion, I asked students to organize themselves into groups of 4 to continue their reflection on teaching and learning in a small group activity (Figure 7). I gave them the following prompts:

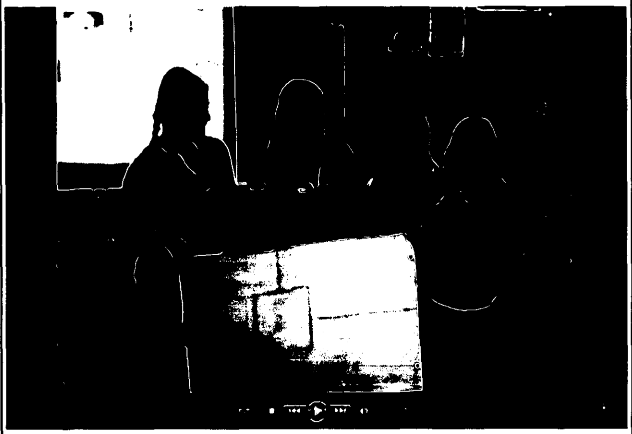
- Choose three (3) pictures. What is the teaching/learning relationship between the people in the pictures? Who has control of the learning?
- Which picture(s) show the best way to learn science? Why?

***Figure 7.* Students working in small group reflection activity.**

Each group recorded their work on large chart paper. In the example represented by Table 7, students reveal some of their thoughts in answer to question 1.

Table 6

An Example of a Group's Response to the First Question in the Small Group Reflection Activity

<table>
<tr><td colspan="4">Question 1: a) Choose 3 pictures. What is the teaching/learning relationship between the people in the pictures?
b) Who has control over the learning?</td></tr>
<tr>
<td>
Fatima: pictures 5, 17, 2– a) I think that picture number 5 the girl is teaching the little boy and she is learning as well – learning is all around. The second picture the man is the teacher helping the girl and she is happy learning. Number 17 has a teacher explaining to them the teacher has all of the learning.

b) All of them have teachers that have control of the learning. All of the people are learning new things.</td>
<td>Sushmitha: 5, 17, 2 – a) I think the relationship between the people in all pictures is the teacher is teaching the students something about science or nature or exploring. But one thing that remains that same learning and teaching.

b) I think our great people, scientists, masters, teachers who first started the education and passed it on to kids to become teachers. I think the teacher has control of learning.</td>
<td>Riddhi: pictures 5, 17, 2 – a) I think teaching is everything because nature (environment) is teaching in picture 5 you can teach people by learning from science that is showing in picture 2 and you see that the man is teaching the girl about science. And in picture 17 a person learned something new and want to teach the world and the younger ones so they can tell others. You learn something new everyday so you forward the news. In all the pictures its all telling if you make a mistake you learn from it, you learn from everything books, experiments, nature, etc. The relationship is that they are teaching and people are learning something new.

b) Everybody is in control of learning and teaching. The relationship is also that someone is teaching them and they are happy to learn.</td>
<td>Audrey: 5,17,2 – a) I think the learning relationship between the teacher and the student is that the teacher is having fun teaching the student and the student is having fun learning.

b) I think the teacher has control over the learning because the teacher is teaching the student and the student is learning what the teacher is teaching.</td>
</tr>
<tr><td colspan="4">Concluding group statement: We agreed that the relationship between the people in the picture is that the teacher is teaching the students new things. We also agreed that the teacher has control over the learning.</td></tr>
</table>

In this sample of group work, one can see that the four group members identified participants in the role of teacher and learner in each photograph. Three of the four group members believed that the person in the role of teacher controlled the learning. In addition, their responses echoed some of the ideas that were discussed in the large group setting. These include the ideas that: we can learn from exploring, experimenting and books, teaching and learning is everywhere, and we learn in order to teach others. This sample of group work is a fair representation of ideas and thoughts from other groups in the class.

Students concluded the lesson with individual reflections in their science journal. They reflected on the following meta-educative questions:

- In which situation can **you** learn the most?
- Which learning situation is most comfortable for **you** (physical/emotional)?
- Which learning situation do **you** like best? Why?

Analysis of their reflections indicated that the first and third question elicited similar responses from students. They consistently wrote about learning situations where tools or hands on experiments were used, and some even wrote about lessons where I used Power Point. Students responded to the second question by focusing on their physical environment. The responses ranged from describing the benefits of learning science outside to learn about the environment to learning indoors with no distractions.

6.2.3 Exploring the concept of equality. The subsequent class explored the concept of intellectual equality through Jacotot's Story. This yielded a very interesting class discussion. The class was intrigued as I explained what equality in intelligence meant in the classroom context. A collective gasp was audible when I further explained, that in reality, this meant that they were all equal to each other's intelligence and to my own. This was promptly followed by the question, *"So you mean a grade 6 student is smarter than the teacher?"* Some laughs and chuckles were expressed at this thought as well as earnest eyes inquiring at me. I must admit that even though I was striving for the student/teacher relationship to be redefined in this journey and knew that it involved a shift in power relations, part of my teacher-self was not so amused at some student's willingness to *'play'* with this idea so readily. I realized even as I was conducting this lesson, the antagonism within me between the *'old master'* and the *'new'* as I struggled with what Power's (2010) referrers to as the "erotics of pedagogy". She comments:

> "Even if the more straightforwardly oppressive elements of education are stripped away, the erotics of pedagogy, and those forms of hierarchy that are predicated on a romantic attachment to the teacher on the basis that he or she 'knows more' than the student are hard to deny and perhaps even harder to prevent" (p. 7).

"*Are we equal to celebrities?*" asked another [Field Notes, January, 8/09]. In response to these types of questions I talked about equal intelligence as being the equal ability to learn and we discussed the fact that we all have this equal ability to learn. We discussed how this type of equality does not necessarily translate to what we do, the money we have, or our status within the community.

I posed a question asking if school showed our equality? I was very surprised that many students immediately expressed that school is *not* equal. They launched into a discussion about report cards. There were those who expressed that report cards 'prove' that students are *not* equal. However, I was intrigued by the students who picked up the concept of equality and ability, and countered with examples of how report cards do not show ability (several citing Einstein as an example). It was students who initiated the conversation about how a person's will or motivation is the key to learning and cited several personal examples of when they had the will to learn something and when they lacked the will and motivation to learn something else. They also discussed that what a teacher values is also a factor in learning. It was very clear that despite any best effort by a teacher to appear impartial, students recognized that teachers sometimes placed more value on some subject areas over others.

6.2.4 Moving towards emancipatory practices. Students were given time to reflect individually on the topic and generate question(s) that they wanted to explore. Students then shared questions with group members to provide peer feedback. This allowed for the sharing of ideas and refinement of questions. This represented the only time in the process where all students were focused on generating questions collectively. Since students individually paced themselves through the model over several iterations, each student generated a new question when they determined the previous question was sufficiently researched.

The lesson also included a review of finding "informational" science text. Through class discussion students determined that they could be found from sources such as, books and magazines from the school library, the public library, personal collections, the classroom collection, articles, and websites from the internet. Based on their previous learning in media literacy over the year, we discussed and reviewed how to critically analyze a website for content. In this model as the emphasis is on student self-learning, we discussed the importance of students' responsibility to search for and bring their texts to the class. As previously mentioned, although the students were predominately English language learners, I did not suggest, choose or restrict the use of any resource for any student. There was an expectation set that there would be a higher demand on students in terms of participation, personal responsibility for learning, and intellectual effort. In this study students primarily used textbooks from the public and school library and informational text from science websites.

6.3 Phase II – Reading as Inquiry (Iterative Stages of Interactions With Text)

As the previous chapter outlines, Phase II, the inquiry phase consists of three stages of interaction with science texts. These stages of interaction are:

1. Inquiry Through Text
2. Inquiry With Text
3. Inquiry About Text

6.3.1 Inquiry through text. The primary focus of this stage aims to nurture the independent reading of science texts. The components include 1) students determining their own inquiry questions within the topic of study, 2) choosing their own informational science text to research their inquiry, and 3) reading the text with guiding questions in mind.

Determining Inquiry Questions. As students cycled through the stages, they decided when their questions were sufficiently answered. They would then choose their next inquiry. For example, during a student/teacher conference, Andrea determined that she answered her question satisfactorily, and her next goal was to communicate what she learned through a written piece of work. As she was deciding what form her writing piece would take, she was also in the process of formulating her next inquiry. The following is an excerpt that represents one of her experiences [Transcribed from video data recorded on February 17/09]

> T: How're you doing?
> S: *Good, I just need to come up with a question.*
> T: So where are you right now? How many questions have you done?
> S: *I did 2 questions and a good copy.*
> T: So you're thinking of your 3rd question now?
> S: *Yes.*
> T: Alright, so I think I already looked at this with you – your 1st and 2nd question. So did you have a chance to reflect on – take a moment to reflect on your general learning?
> S: *Uh, yeah.*
> T: So what do you think your 3rd question is going to be?
> [Long pause]
> T: How are you coming up with the question? Have you thought of anything yet?
> S: *No.*
> T: Anything at all, anything about space? From researching these two questions, did it make you think of something else you would like to learn about?
> S: *Umm, not really.*
> T: So as a goal today you're trying to come up with a 3rd question? Alright, so I'll check with you after that.

Andrea's conference suggests that students needed time and space to think and direct their learning. Giving students this unstructured time was something that I internally struggled with during the course of this study. My professional journal contains a series of entries that reflect on this theme. My urge was to suggest a question knowing that she would accept it since it came from the teacher. However, I restrained myself with the knowledge that it would be unnecessarily asserting my control over her learning. Through this process, I found that students needed time to think about and finalize which questions they would work on. This process took the form of talking to others and sharing text resources.

Reading Text. Throughout their learning students were excited to share what they learned with other students as they were reading and felt comfortable expressing any difficulties they had finding information to address their questions. As a result, students willingly shared these resources and traded books throughout the term.

Initially, I was unprepared for the social aspects of learning in this model. When I observed students talking to others about what they were learning *while* learning, and passing books around the classroom, I perceived it as a lack of focus to the task and held concerns about classroom management. I did not anticipate that learning by oneself would also still involve a sociocultural aspect of learning between students and initially did not recognize the importance of the shared literacy experiences. I observed on numerous occasions that students eagerly and with excitement, interacted with peers through purposeful conversations and shared resources as they constructed their knowledge. As students dialogue about text, it promotes cognitive interaction about the text, as they benefit from other people's perspectives, which in turn supports the making of connections and clarify understanding. The only classroom management issues were around the level of noise as this sharing took place.

Some students articulated this perspective in the following ways:

Mohammad, in his interview [March 10/09] expressed,

> The first term was fun because of the hands-on and building. In the second term we talked more to people about ideas. There was more interaction.

And Navneet who in a journal reflection writes,

> This leaning process was a lot fun because we got to share things with our teacher when we conference with them and with the class when we were researching.

In order to compare the opinions of authors, students did use more than one text to answer a question. For each text, they were led through the use of their journal, to keep the guiding questions in mind as they were reading since they would later respond to the questions in their journal. Students typically read the text first and then responded to the questions after reading. The process required students to re-read the text to document their work accurately.

6.3.2 Inquiry with text. The second stage is characterized by 1) students documenting what they learned and reflecting on their learning in their science journals and 2) communicating what they learned through a writing piece.

Science Journal. For each text, they read, students documented what they learned (guiding questions) and reflected on their learning in their science journals. Figure 8 illustrates the left side of a student's journal, which documented what they were learning from a particular text. Figure 9 illustrates the right side of another student's journal, which details their reflections on their reading and learning processes.

Question: How does weather in outer space effect earth and every day life on earth?

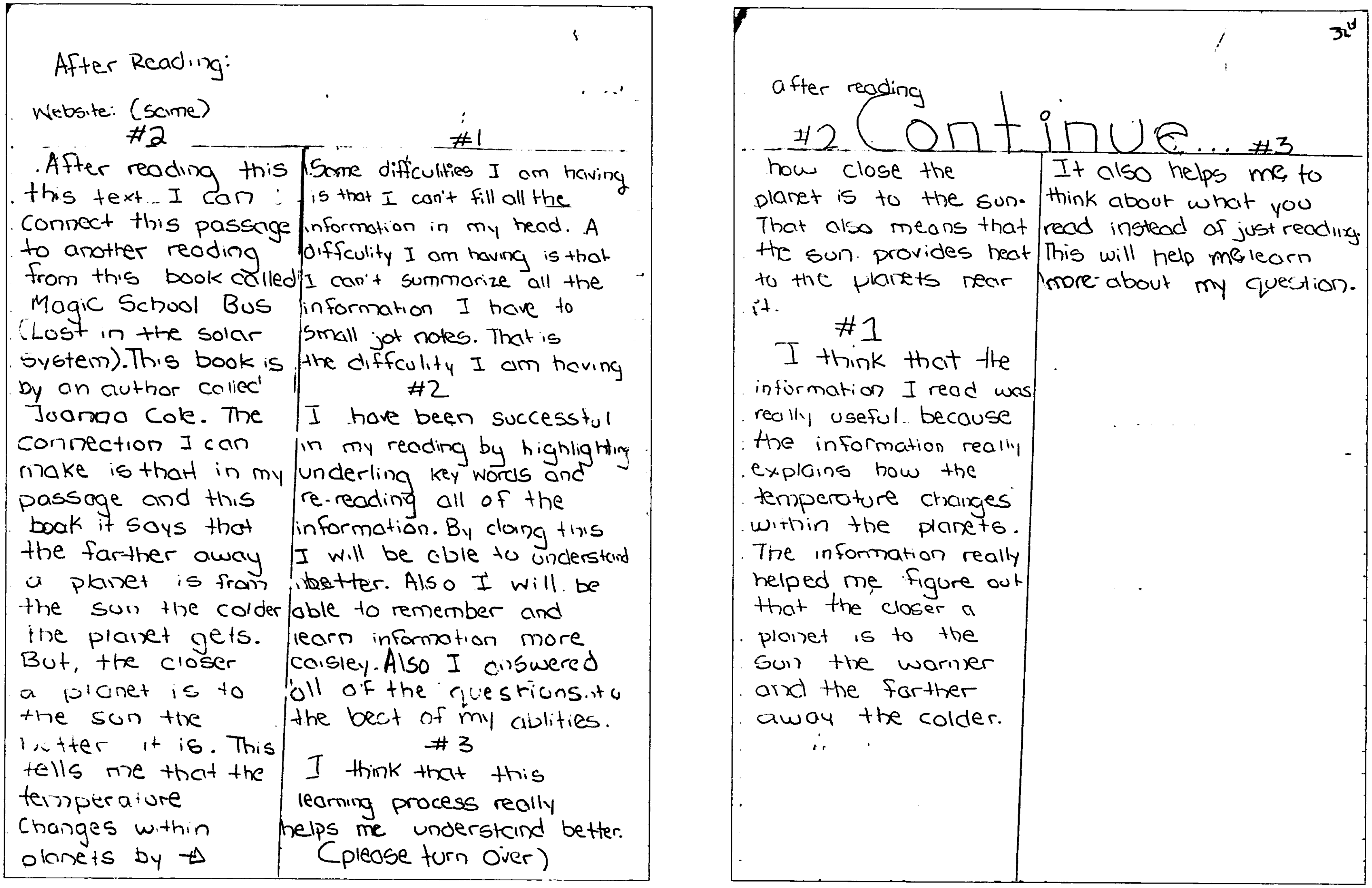
Book: www.exploratorium.edu/spaceweather/sun.html

Left Side:

What did I learn from the author?	How do I know this? (proof)
I learned that 1. Shortwave radio communication works by bouncing radio signals off a charged layer of particles in our atmosphere called the inosphere. Geomagenitic storms disturb the inosphere making the radio communication impossible. 2. Most navigation systems depend on the GPS which in turn depends on satellites that send carefully timed signals to the GPS. Geomagnetic storms cause sudden variations in the density of the inosphere. As a result GPS signals from satellites arrive either too late or early to the GPS. Also, geo magnetic storms may affect	I know this because on the website it says 1. "Shortwave radio communication (used mainly by the military and for long range broadcasts) works by bouncing radio signals off a charged layer of particles in our atmosphere called the inosphere. Geomagnetic storms disturb the inosphere making radio communication spotty and sometimes impossible." 2. "Most Navigation systems rely on GPS, the Global Positioning system, which in turn relies on carefully timed and triangulated signals from satelites. Geomagnetic storms

animal navigation too. Many migratory animals have things called internal biological compasses thanks to tiny grains of a magnetic mineral (called magnetite) in their brains. Geomagnetic storms can disorent these animals, causing whales to beach. 3. I learned that geomagnetic storms induce in the cables and transformers of electric power systems. These currents can damage equipment causing power failures like in Quebec in 1989 a geomagnetic storm caused a black out leaving 6 million people with out power.	cause sudden variations in the density of the inosphere. As a result, GPS signals from satellites arrive at GPS receivers slightly early or late, leading to inaccuracies. "Meanwhile, geomagnetic storms may affect animal navigation too. Many migratory animals have internal biological compasses thanks to tiny grains of a magnetic mineral (magnetite) in their brains. Geomagnetic storms may disorient these animals, causing whales to beach and carrier pigeons to lose their way." 3. I know this because in the text it says "Geomagnetic storms induce electric currents in the cables

Figure 8. **Example of the left side of a student's journal documenting what they learned from a text.**



After Reading:

Website: (same)

#2

.After reading this this text. I can connect this passage to another reading from this book called Magic School Bus (Lost in the solar System). This book is by an author called Joanna Cole. The connection I can make is that in my passage and this book it says that the farther away a planet is from the sun the colder the planet gets. But, the closer a planet is to the sun the hotter it is. This tells me that the temperature changes within planets by →

#1

Some difficulties I am having is that I can't fill all the information in my head. A difficulity I am having is that I can't summorize all the information I have to small jot notes. That is the diffculity I am having

#2

I have been successful in my reading by highlighting underling key words and re-reading all of the information. By doing this I will be able to understand better. Also I will be able to remember and learn information more easiley. Also I answered all of the questions to the best of my ablities.

#3

I think that this learning process really helps me understand better.

(please turn over)

3rd

after reading

#2 Continue...

how close the planet is to the sun. That also means that the sun provides heat to the planets near it.

#1

I think that the information I read was really useful because the information really explains how the temperature changes within the planets. The information really helped me figure out that the closer a planet is to the sun the warmer and the farther away the colder.

#3

It also helps me to think about what you read instead of just reading. This will help me learn more about my question.

Figure 9. **Example of the right side of a student's journal detailing their reflections on their reading and learning processes.**

Students cycled back through this stage when they concluded after the student/teacher conference in phase 3 that the question was not sufficiently answered. Students would either return to one of their texts for further examination or read a different text and author to further answer their question. New learning and reflections were added to their science journals.

An example of this process is found in the following excerpt from a student/teacher conference with Noura [Transcribed from video data recorded on January 22/09]. This excerpt offers an opportunity to reflect on my attempt to have Noura verify what she learned by referring back to the author's words in the text as well as encouraging reflection on her reading strategies by explicitly asking her about them.

T: O.K. Noura why don't you tell me what you've been doing so far.
S: *I've been researching the question, what are Saturn's rings made of? I have some information so far.*
T: O.K. so what's the text you started with?
S: *It's called, Our Solar System.*
T: Whose it by?
S: *Semour Simon*
T: O.K. and what was the question again?
S: *Uh, what are Saturn's rings made of.*
T: Alright.
S: *I learned that Saturn's rings are made of pieces of ice and dust and small pieces of rock. They are probably from the moon that were chipped off by meteorites that were passing.*
T: O.K.
S: *In the text it said that, you would see that the rings are made of pieces of ice. In another sentence it says, perhaps pieces of nearby moons that were chipped off by incoming meteorites helped form the rings.*
T: How did you know this information? What did the author say? What you told me was that quoting from the author directly?
S: *I put it in my own words.*
T: So what did the author say about Saturn's rings?
S: *He said that was made of ice and some ice from pieces of rock from the moon.*
T: Did you find this information hard to get from the text?
S: *It wasn't necessarily the information it was more of finding something that had to do with my question.*
T: Well, O.K. So what strategy did you use? Did you read everything first and then just narrow in on the information that related to your question or did you look first for information that related to your question?
S: *Um, I first started to scan the information then I found some information on Saturn's rings.*
T: So do you think the information you have so far answers your question?
S: *Not fully.*

T: So are you going to continue with this author and reading that particular text or a different text?
S: *A different text.*
T: So do you have the text you're going to look at?
S: *Yeah.*
T: Did you do your reflection questions from before?
S: *You mean for my other questions, the second one?*
T: Yes.
S: *Yeah, I did.*

Noura went on to use an additional two other texts to answer this particular question. In her science journal, she compared the information provided by the authors in each of the texts.

Writing Activity. Once students determined that they satisfactorily answered their question they chose a writing form to communicate what they learned. Students choose to represent their work in a variety of forms from reports to creative writing pieces. Regardless of the form students were encouraged to authentically communicate and share their learning with not only members of their class but to friends and family as well.

Figure 10 is an example of a student who chose to represent what she learned through a creative writing piece, specifically, a children's book. The piece is based on one of her research questions, which asked, "What are planets made up of?" In addition to sharing with the class, she sent her work by email to her cousin in India. Her cousin's response is included.

The Planets Interview

Good Morning. Today I will tell all of you people that are reading (if you are a human you might know all this but if you are learning I will be happy to help you)so where was I ...Oh yeah I will tell all of you about my little friends "The Planets."So I will go to each person's house and interview them. First let's go to Mercury's house. He offered me coke and let me tell you one thing that I never say no to anything! So later on I asked her "What are you made up of?"She replied "Rocks." Then I asked him how he knew that he said the humans told him. They researched a lot on him and told him. Next I went to Venus and I said" long time no see Venus." He offered me coffee then I asked him the same question and he said the same thing as Mercury, exactly the same. So then I went of to my best friend "The Earth" when I asked her the same question she said "well I am made out of rocks and water" "oh how can you say that" I asked her she told me since the humans are so close to her they decided to tell her. Next in my list was Mars the red planet. He offered me tea. When I asked him that question he said the same thing as the other two. Next was Jupiter he was huge and offered me two bubble teas. He said he is made out of gas and rock. Obviously he had the same story as the rest. Later I went to Saturn and I wondered how many times its married it has so many rings (lol) get it so many rings ha ha ha. Well she offered me juice and I asked her the question she said that she is also made of

Figure 10. **Example of student creative writing.**

rock and gas but her rings are made out of ice. So then I went of to Uranus and she is just lovely she is so sweet she offered me sprite and I asked her the question she replied that she is made out of gas, rocks and deep oceans. Neptune was also awesome she told me that she is made out of gas and rocks and deep oceans just like Uranus. When I went to Pluto he was so small that he never offered me anything so I never asked her anything. Then when I went home I realized that I never asked any of my friends the important information so I call all of them with my I phone and they all came I felt bad for Pluto so I called him after all I am the sun always bright. Here are my answers in a organized way the sun style

1. Mercury is made out of rocks and there is little, if any atmosphere.
2. Venus is made out of rocks and there is little atmosphere.
3. Earth is made out of rocks and the atmosphere is water.
4. Mars the red planet is made from rocks only the humans are still searching about the atmosphere, they send two rovers sprit and opportunity to see what Mars is like
5. Jupiter is made from gas and rocks he just told me that only the center part is rock the rest is gas. The gas ammonia in the planet cause's colourful clouds in Jupiter.
6. Saturn is made up of gas and rock, like Jupiter Saturn also has only the center as rocks but the rest is gas.
7. Uranus is made out of deep oceans, gas and rocks the name of gases are Helium, Methane and Hydrogen.

8. Neptune is like Uranus. It is also made up of frozen gases and rocks. Helium, Methane and Hydrogen

9. Pluto is made up of rock and ice there is very little atmosphere.

Interesting facts

1. Did you know that Saturn and Jupiter have center rocks twice as hard as the sun's surface!

2. Like Jupiter and Saturn Neptune and Uranus also have the center only as the rock.

Hope you enjoyed learning about the planets.

Done by: (the sun)

Dear

Your project was quite interesting and I got pretty much engrossed in it. Looks like you've done a lot of research for it, and also put in a lot of hard work. And yeah, it was creative too. I especially loved the sun (you) interviewing the planets. That's a really good way of learning about space. You've also added a bit humor to it, which makes it fun to read. The facts at the end were quite interesting. I got to learn a lot of things from your project which I never knew earlier. That was what I thought about your project

Keep up your good work!

Well done

(big sister) lives in India and is in grade 8 and will turn 14 in April. She responded to my e-mail that I send her about the project on 6th of Feb. She is a very smart child but I think the project I send her has some information She never knew. She responded to my e-mail in a very sweet way and She is one of my best cousins because I have learned a lot from her. She is like my sister and I don't feel She is my cousin because she is So close to me.

The cousin's response to the student provides an authentic reader's critique of the work citing attention to research, creativity and appealing format of the creative writing piece.

6.3.3 Inquiry about text. Inquiry About Text, the third stage of phase II, more formally engages students with their teacher and peers. Students have a further opportunity to process what they learned and determine the validity of their conclusions as they communicate what they know. In this stage, this is done through 1) student/teacher conferences and 2) sharing their writing pieces with their peers.

Student/Teacher Conferences. The conferences were conducted with individual students throughout the science periods as the other students were working through the different phases of the model. I began each class creating a list on the board of those who were ready to see me. The length of the conference was determined by the student based on what they had to talk about. I consciously put a table in the room aside for this purpose, as opposed to meeting at my desk. We sat side by side for conversation and to see and discuss the science journal and/or text (Figure 11).

Figure 11. **Student and teacher view from the conferencing table.**

In this section, I will focus on 2 samples of the student/teacher conferences to give a flavor of this learning relationship. These examples were chosen to show the types of exchanges and practices as students cycled through the process at various stages of their learning. The following samples are transcribed from video data.

Muhammad [Transcribed from video data recorded on February 3/09, Phase II]

This is one of Muhammad's conferences that take place midway through the unit. He is a highly motivated student who exhibits a high degree of participation in class. He is one of two students who, in anticipation of the Space unit second term, did an extensive hour-long overview of the space topic using power point. Muhammad is a student in stage 4 of English language acquisition for reading and writing. His first language is Gujarati, which he speaks at home along with Hindi.

I include this fulsome section of conversation to capture the flavor of the student/teacher conferences since they are an integral component of the model.

1. T: So how's it going Muhammad?
2. S: *Should I go to my 2nd question or 3rd question? I'm working on my 3rd question but the 2nd question I'm finished.*
3. T: O.K. let's go to your 2nd question.
4. S: [Referring to journal] *O.K. so my question was, um, what are the characteristics or attributes of a black hole in order for it to produce time travel? Um, so what I found out from one book, "The Universe", the author was – I couldn't find the exact author, the publishing date was 2006.*
5. S: [Not referring to journal] *So I learnt that when you're travelling in space, time actually slows down. Space travelers age more slowly than they do on earth or people on earth. Albert Einstein figured this out in 1905 before we actually started flying in space and he knew that the speed of light never changes – its constant – so it never changes. It always travels at one hundred and eighty six thousand miles per second and he said time is relative and it can change. It changes according to the speed of what is measuring it. So the faster the speed, the slower the time travels and vice versa.*
6. S: [Referring to notes]*And um, they actually test this out going back on Einstein's theory. They put a very accurate clock aboard the space shuttle*

which measured after its return to earth and while it was travelling great speeds in space it lost 2.95 x 10(-10) seconds. That's how much they lost. Now this seems like a very tiny amount but it proves that Einstein's theory was right and this proves that if the space shuttle had been travelling the speed of light it might have gone for several years – the time lapse would have been way bigger. So if you went on a very long space trip, traveling close to about 186,000 miles/sec, you would be younger than when you first started when you return.

7. S: [Referring to journal] *And then yeah, this is my reflection.*
8. T: If I could just stop you before you go onto your reflection – if you were to go back and answer your question which was, what are the characteristics or attributes of a black hole in order to produce time travel, how does this information relate to your question?
9. S: *Um, this information doesn't have anything to do with a black hole but it goes back on Einstein's theory using his theory of relativity in the course of space travel – time travel and space – so this doesn't have anything to do with a black hole. My main achievement – my main object is actually to just find out about time travel in space. How does it slow down, how do you age more slowly and why do you, how does it happen and all that. But yeah on the next page if I go – the black hole question is answer 2 over here.*
10. T: So this was part of your –
11. S: *Yep, this was part of the other book too. This is part of the information for the 2nd question.*
12. S: *Yes and I found a book by the author Carl Sagan whose main character is a relativity expert who can travel to distant stars and planets. He returned to earth to find that no time had passed on earth. He [Sagan] replied that the character travelled through a worm hole through space and time. Some scientists are still examining if worm holes actually exist – I myself don't actually think that worm holes exist. I tried to find out if they did.*
13. T: Now this book by Carl Sagan – what was it called?
14. S: *Contact.*
15. T: Was it a factual book or was it fiction.
16. S: *It's nonfiction.*
17. T: Nonfiction?
18. S: *Oh, no, no, no, I mean its fiction, yeah its sci-fi.*
19. T: So why did you choose to get information from a fiction book as opposed to a factual book?
20. S: *Because a factual book would first be blunt and direct and say like – there's no such things as worm holes or they are normal. I want to see how he conducts this experiment of actually, like, making the character feel that he is going through a worm hole. I wanted to see how it might feel to go through different dimensions and time.*

21. T: O.K., so getting an author's opinion of what it might be like, but in terms of the science behind it and talking about worm holes the possibilities of that – would you take scientific fact from a fictional book?
22. S: *Um, in a fictional book that would be hard to say – there are some scientific facts even in a fictional book – you just can't make a fiction book on your own there has to be some science facts in it. I didn't actually read this book I just did a bit of research on it and found that some of the facts I researched in my space project (other question) were relative – relative information was in here (Sagan) too. So I know that that scientific information is right.*
23. T: So you've had experience checking that information with other authors?
24. S: *And with NASA discovery (website) – they're usually accurate.*
25. T: So now in terms of explaining this part of the question relating to the black hole. It is interesting that you added a perspective of what it could be like from an author's point of view. So in terms of the science now behind it – the facts related to the characteristics of a black hole, how are you going to proceed with getting accurate scientific information.
26. S: [referring to journal] *Accurate scientific information I found – I didn't actually find anything else for - like on the next page it says on page 63.*
27. [*reads paragraph recorded in journal from book*]
28. T: Now is this from Carl Sagan's book?
29. S: *No. I have the book in my bag. Should I get it?*
30. T: No, it's O.K. So this information is from a different factual book?
31. S: *And it says, [reads another excerpt from the book recorded in his journal]*
32. S: *Then in my book and Zareen's book it shows a picture or example of a worm hole – what it would be like. In my book they show this worm coming out of this hole – just for fun – and they show like these ripples in space and they show one part of the worm [gesturing] way over there and the other part way over there and it shows him wearing a beard and everything because he's old and everything so it shows a picture of that.*
33. T: So have you compared this information with any other author?
34. S: *Umm, no. I wouldn't say yes. No I really haven't compared it. Well I think*
35. S: *I compare a little of these facts with the information on the next page here*
36. [referring to pages in his journal].
37. T: So then you have but you just didn't write it down. O.K. good. It would be good to write it down just for tracking purposes. So you remember what you compared and what you compared it with. I would recommend just making a record of that particular book and that author and what you compared so when it comes to answering your question you

have nice rounded information and you can track which author you compared.

38. S: *And then my 3rd question. I'm working on is how would space in the future be? Like space travel, space living and everything. What I found is this, this and this* [flipping through journal]. *I'm still working on it from one book.*
39. T: O.K. good. So I'll touch base with you on your 3rd question but you're going to do some documentation on your 2nd question.
40. S: *Great, thank you.*
41. T: O.K.

Muhammad's sample is in some ways typical of the student conferences throughout the unit. It typifies the behavior I was cultivating where students would share their learning while I verified their search for information and understanding. In this example, our discussion (lines 14-32) regarding the use of a fictional text to learn science was very intriguing to me even in the midst of participating in the conversation. The exchange perhaps illustrates Muhammad's 'freedom' to express his creativity and imagination in his use of different texts as he constructs his own knowledge in his science inquiry. As my journal notes, under my previous system of teaching and learning, Muhammad would not have had the opportunity to develop his thinking and explore for himself, the benefits or limitations of using such a text alongside a factual text. Previously, I would have recommended or chosen the books to be used and would not have included a science fiction text for research purposes. I found his use and justification an interesting insight into his thinking.

Samrin's conference also took place midway through the unit and exemplifies that verifying that a student has searched for the answer and information also encompassed verifying that they had diligently search for meaning or understanding in the words themselves. Being a teacher of English language students made me acutely conscious of this aspect of verification. The exchange between Samrin and me is typical of several conference conversations with students.

Samrin [Transcribed from video data recorded on February 5/09, Phase II]

Samrin is a student new to Canada. His first language is Marathi, which he speaks at home. Samrin is in stage 1 of English language acquisition for reading and writing. He likes to work alone and is very dedicated to his studies in school.

T: So what was your second question?
S: *Um, what is a galaxy?*
T: What were the books and texts that you used to find out information?
S: *I used this book [pointing to name in journal]and got information from there.*
Was that the only text you used?
S: *Yes. Because it had each and every information and even it had the main galaxies.*
T: O.K. So why don't you take me through [Referring to his journal]. These are the notes from what you learned?
S: *Yeah. These are the four main types of galaxies, elliptical, spiral, barred spiral, and triangular, and I learned about Milky Way. You can see Milky Way with our eyes.*
T: Where did you get that information?
S: *From the book.*
T: What was the name of that author?
S: *I'll go check.*
Wait, when you finish here. Just make sure you go back and check to write it down.
T: What did the author say about what you learned? The different types of galaxies? What he said about that.
S: *The information is here.*
S: *[Reading from book excerpts written in his journal about the Milky Way and types of galaxies*]
T: [I interrupted] What's a spiral?
S: *Spiral is a galaxy.*
T: Is it the name of a galaxy?
S: *It's a disk shaped galaxy.*
T: What does it mean for something to be disc shaped?
S: *Like a CD.*
T: Yeah, like a CD. That's right and how did you know that? Did you know that word before?
S: *No.*
T: So how did you know it's like a CD.
S: *Because sometimes we call a CD a disk.*
O.K. good. You had another interesting science word here – nucleolus.
What is a nucleolus? Do you know what it is? What they mean by that?
[Long pause]

That's O.K. If you're not sure what can you do as a reader if you're not sure about what the author meant what can you do to understand this part better.
I can read it again.
O.K. To read it again and to – if there are some words you're not sure about, what can you do?
Look in the dictionary?
Look in a dictionary – right and use some of your reading strategies. So I think something that would be helpful for when you explain this in the future is to perhaps read it again use the reading strategies so you can have a better understanding of what you're saying.
So what else did you learn? Just tell me in your own words.
[Looking at me and referring to the types of galaxies] – *irregular that means all the stars are scattered pattern and it is not common.*
[Pause] Um, that's it right now.
O.K. so how did you find learning this way. Did you find reading the books difficult that you choose?
No.
You were able to understand them fairly well?
Yes.
So do you think if you go back to re-read some of the parts you weren't quite sure about that you would have success understanding what the author was saying?
Yes, I think so.
Alright, so I'll conference with you again to see how you're doing.
O.K.

In this example, I followed up with Samrin the next science class to make sure that he used a dictionary and to clarify any other misunderstanding of vocabulary words. At times, the conference was just an opportunity to encourage students to keep on track with their learning.

Sharing What Was Learned. Students communicated what they learned by sharing their writing pieces either with me in the student/teacher conference or with the class and members of the larger community. Several students sent their work by email for feedback from fathers or other relatives who were abroad. The positive feedback and reinforcement of their effort was a very powerful motivating factor to continue their learning.

6.4 Phase III - Exploring and Reflecting on Intellectual Emancipation, Teaching and Learning

In this reflective phase, we revisited the concept of teaching and learning discussed in phase I. Students worked in the same groups to reflect on the original images with a question to identify any changes in their perceptions of teaching and learning. The groups recorded their ideas on a chart paper template (Table 8). The table represents the work recorded by one group. Students were invited to share their thoughts with the class.

Table 7
Example of Group Recordings

Before we thought that...	**We still think that...**	**Now we think that ...**
Question: In which pictures are people learning science? Why?		
Everything in the pictures is science We thought that science is about looking, exploring and examining, reading, discovering, studying, finding, and experimenting. Science is about experiencing Science is about nature We thought scientists invent everything.	Everything in the pictures is science We thought that science is about looking, exploring, examining, reading, discovering, studying, finding, and experimenting. Science is about nature	All of them because science is about exploring, framing, reading, discovering, studying, finding, experiencing. Also, we think they are all pictures [of learning science] because science is never about only scientific tools or only scientist or doctors who are the best at science. Science is everywhere in the world and you can learn science from many things like nature and books and experiencing. Anyone can teach you science We thought scientists invent everything but any ordinary person can invent something.

Another group shared their responses with the class. They are pictured below in Figure 12.

Figure 12. **Group of students working on responses.**

[Excerpt transcribed from video data recorded on March 10/09 from the group in Figure 12]

In the beginning of the unit we thought that it would be bad but realized now that we are at the end of the unit that we learned a lot. Thought it would take so much work to bring research but it was actually easy and we got so much information and learned a lot. [The students initially perceived a significant amount of work at first believing that it would be difficult finding texts, but it turned out to be easier that they thought].

In addition, students filled out a Science Portfolio Reflection Questionnaire and Research Process Rubric (Appendix F and G). To conclude the research study I conducted and videotaped the student interviews to document their learning experiences over the term. The interview questions are documented in Appendix H.

6.5 Interlude

In the previous chapters, I outlined the problematic of the study and discussed the issues in the context of the relevant literature in the field. Next, the rationale for the study's methodology was discussed, and details of the methodology and data analysis were described. Thereafter, the Pedagogical Model of/for Emancipation was explained followed by the description of its implementation. The next chapter provides a descriptive analysis of the data collected in the study.

In addressing the research questions, a number of themes emerged through analysis of the data. Since I analyzed my class as a case, I included all students in the analysis. I used a thematic analysis approach, which layered the themes. The analysis represented in the following chapter reflects the triangulation of the data from different phases of the model, using student journal responses, discussion responses, interview video, student/teacher conference video, student questionnaire, and the research process rubric. The chapter is organized thematically to reflect the experiences of the participants that emerged from the data analysis.

CHAPTER SEVEN

ANALYSIS

7.1 Introduction

To recapitulate for a moment, this study seeks to nurture intellectual emancipation by encouraging students to take increased control over their learning through the application of their own intelligence. The goal of the intervention is not to prove that this model is better than other methods (or models) for teaching and learning science, but rather to investigate how students learn science through emancipatory pedagogy within a model of inquiry that focuses on reading.

Where Chapter 6 describes the implementation of the lessons and highlights the ways in which the action research and my pedagogy sought to recognize equal intelligence, Chapter 7 analyzes the data collected through the three phases of the model as a means to reflect on and explore the efficacy of the experiment. Specifically, this chapter seeks to answer the following research question:

> **What are the effects of the changes in my practice on student learning?**
> In what ways do students demonstrate, or not demonstrate, their intellectual emancipation? How do students learn science concepts?
>
> **What are the effects of these changes for teaching and learning?**
> In what ways do these changes influence my relationships with students? How does it affect my teaching belief systems? To what extent do I become using Rancière's term, an 'ignorant schoolmaster'?

In responding to these two questions, I realize that my reasoning or argument is syllogistic (from cause to effect) and can be approached from two subtle but different perspectives. For example, I could start with the focus on me as teacher-researcher and analyze the ways in which changing my practice affected me as an instrument of teaching. I would, therefore, propose that if I found evidence that I changed my teaching belief systems and relationship with students, I would see corresponding evidence of my students moving towards 'intellectual emancipation'. However, if I choose to start with the focus on the students and evidence of their demonstrated intellectual emancipation and learning science, I would propose that if I observed evidence of 'intellectual emancipation,' then I could infer that I had some success in moving towards being an 'ignorant school master'.

I chose the latter perspective in analyzing the multiple sources of data (Chapter 4). In examining the data, I believe that student behavior and their reflections *on* and *of* their learning as expressed in their own words are an appropriate source of evidence that provide useful markers of how intellectual emancipation may or may not be expressed. I acknowledge that I am operating under certain assumptions. For example, I assume that there are behaviors associated with intellectual emancipation and that these behaviors are observable. I also acknowledge that my interpretation of these behaviors and students' own accounts of their learning are based on our partial understandings of our classroom experiences. That is, one's description of any experience is a partial account or interpretation of that experience. As Wallace and Louden, 2002 explain, there are two ways in which a teachers' knowledge of their own teaching is always incomplete. It is incomplete based on the fact that all knowledge is incomplete. That is, knowledge changes imperceptibly and constantly with each new experience allowing for the possibility of new understanding. In addition my knowledge is incomplete because it is personal knowledge. Wallace points out that this individual knowledge that is used to negotiate the world is different in crucial ways from other teachers working in the same environment or similar environments, and from students. I can never fully know the learning experiences or knowledge of my students because I do not have direct access to my students' experiences, but rather, only to what I take to be my students' reactions to my teaching (Wallace & Louden, 2002).

Nevertheless, I believe that students' accounts of their experiences offer a firm basis for which to reflect on my practice.

Two major themes arise from my analysis of the data: (1) evidence of students' will to learn and (2) how students learned science. The first part of this chapter focuses on the manifestation of students' will to learn as expressed in their self motivation, self-efficacy, and independent engagement with their text. The second part of Chapter 7 focuses on how students learned science. That is students' (habits) metacognitive reflections on learning as expressed in their articulation of how they processed information through strategies such as comparing different texts, formulating opinions of authors, the use of prior experiences, self-monitoring for understanding, ability for self-learning and evidence of their conceptual understanding (Figure 13).

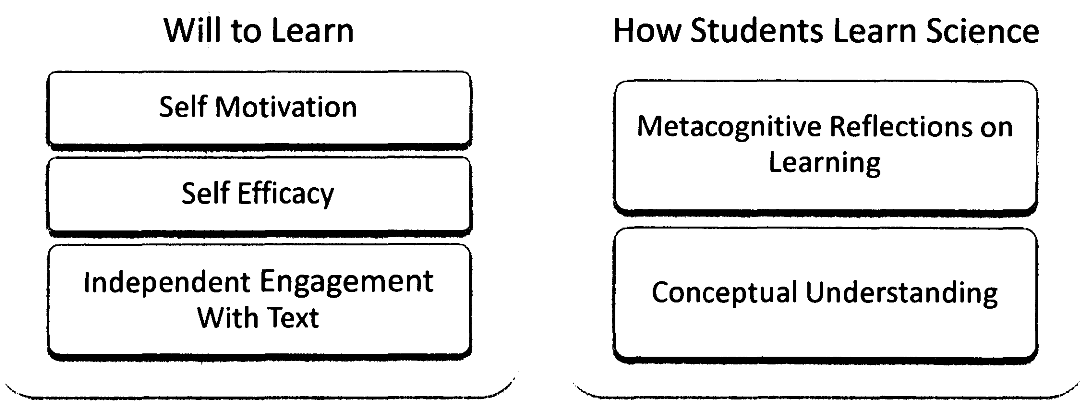


***Figure 13.* Major themes that emerged from the data.**

7.2 Students' Will/Motivation to Learn

Rancière's concept of will is in many ways analogous to the more commonly referred to the concept of motivation. Motivation, from the Latin verb to move, is a process where a goal-directed activity is sustained. In a similar vein, the "power to be moved" (Rancière, 1991, p. 54) is also found in will. That is a person's will is served by an intelligence, which is the amount of attention given to a situation; "learning is the work of the will" (Rancière, 1991, p. 56). One could argue that the amount of attention a student gives to a situation is determined either consciously or sub-consciously by a goal that they set. Since will and motivation are similar concepts that can only be inferred and interpreted rather than observed directly, I do not make a specific distinction between the two for the purposes of this study. In educational settings, motivation is a term more commonly used to discuss students' actions and attitudes toward learning.

7.2.1 Self motivation. Students articulated some aspects of motivational influences by commenting on their feelings about learning science and the value they placed on their learning. For example, Zareen, comparing the information from different authors, reflects in her journal the following sentiments:

Zareen from Journal entry from Phase II – Inquiry Stages:

1st Question

- I only have one thing to say about this process of learning that I simply just LOVED! It and enjoyed it a lot.

1st Question (2nd source)

- I think now I understand what I wrote from the first books information and I feel happy

3rd Question (2nd source)

- When I finished reading I thought and felt happy because this was very interesting and I thought I learned a lot.
- The ideas in this relate almost near to what I wrote in the first source so I am happy!

Nathan reflects a similar feeling despite his own recognition that he requires more work for his question. He comments,

Nathan's Journal entry from Phase II – Inquiry Stages:

2nd Question (source 3)

- The learning process is good because I get to reveal my feelings and I get proof of everything. In some cases like this I still don't have the detail I need.

I was particularly interested in the comments of two students who could be traditionally labeled by teachers as underachievers in academic subjects such as science and language arts based on their school performance reflected in their report card results. Tagbir and Darren expressed not only positive feelings towards their learning but also pride and a sense of accomplishment in the effort they put forth to read. They express,

Tagbir's Journal entry from Phase II – Inquiry Stages:

- I gave an effort and read twice on books.
- I loved it after I got the setup right.

Darren's Journal entry from Phase II – Inquiry Stages:

- I have had successful learning by reading the intire book 2 times and reading carefully for any information or ideas. So the answer for am I successful is, yes.

In the data, students revealed several reasons why this process of learning science was valuable and personally relevant to them. Student comments confirm their motivation to do well and succeed in their learning as well as their personal identification with their questions. This was particularly interesting given that I did not prompt students to work hard or give external motivation to do so as previous experiences with the class suggest.

For example, Andrea and Mohammad illustrate the value they placed on the task by referencing their hard work and the resulting success in their learning. Andrea reflects her persistence despite her difficulty.

Andrea's Journal entry from Phase II – Inquiry Stages:

- I conclude that I worked very hard to find out who discovered each of the planets.
- I had difficulties understanding how Neptune was discovered using "math"
- I have been successful by finding out who discovered each of the planets, but some people don't know who discovered some of the planets.
- The learning process was easy at first, but then became a little harder.

Mohammad's Journal entry from Phase II – Inquiry Stages:

- I have been successful in my learning because I had a very good book and resources. It was also very good because well, I got the answer and that's the most thing that matters and well that was my goal.

In a similar vein Muhammad expresses the value placed on the learning process through his personal identification with a question and topic that held his curiosity for some time. He writes,

Muhammad's Journal entry from Phase II – Inquiry Stages:

1st Question

- I have finally found the answer to my question. I consider this a success because I thought of the question and ponder about it often, and finally found the answer to it!

Muhammad's Questionnaire from Phase III:

- I benefited from this way of learning because I got to research questions I found interesting. I got to research (myself) and find the answers to the questions I have yarned for. It also gives me a sense of accomplishment (I am not bragging).
- This way of learning influenced how I learned. It is a new, different way. This way of learning earns you more knowledge. You research heavily on questions you want to find the answers to.

Additional sentiments are reflected with Zareen, Riddhi and Nadine as they express the value they place on the learning process. They write,

Zareen's Journal entry from Phase II – Inquiry Stages:

3rd Question (2nd source)

- I conclude that this information had lots of things to do with my question and I learned a lot and am interested to continue to learn a lot on this fantastic question.

Riddhi's Journal entry from Phase II – Inquiry Stages:

- My topic had to do on comets because I really found the Haley's comet interesting and that made me want to know more about different comets and when they appear. Now I find astronomy very interesting.

Nadine's Journal entry from Phase II – Inquiry Stages:

- I conclude that as I said before this text was very interesting and it arose many questions in my mind. I also conclude that I now know a lot more than I did before about my topic and I think I will try to answer the questions that are still in my mind right now.

7.2.2 Self efficacy. I observed that students' will to learn was also reflected in their self-efficacy. Generally, self-efficacy is the belief about ones capabilities to do a task or activity. It is an individual's belief about their performance capabilities in a particular context or task (Linnenbrink & Pintrich, 2002). In expecting students to use their ability to learn by themselves and responding to them accordingly, resulted in students acting in response with the belief that they *were* capable of performing and learning in this new context. Table 9 represents the number of students in each category who rated themselves on the Research Process Rubric in phase III. Students filled out this self-assessment as an additional way to reflect on their learning experiences.

Table 8
The Number of Students in Each Category Who Rated Themselves on the Research Process Rubric in Phase III

Category	Exemplary	Proficient	Partially Proficient	Incomplete
Research Question	Wrote clear, creative and interesting questions which fit topic (10)	Wrote clear questions which fit the topic (17)	Wrote some questions which did not fit the topic	**Wrote many questions which did not fit the topic**
Selection of Sources	Identified useful texts from many different sources (11)	Identified mostly useful texts from many different sources (12)	Identified a few useful texts in a few sources (4)	**Identified no useful texts from any sources**
Note-taking	Recorded information which answered all of the research questions (14)	Recoded information which answered most of the research questions (10)	Recorded a lot of information that did not directly answer the research question (3)	**Recorded incomplete information which failed to answer any of the research questions**
Organization	**Notes are neat, easy to read and organized (6)**	**Most notes are neat, easy to read and organized (15)**	**Some notes are neat, easy to read and organized (6)**	**Did not organize notes, messy and hard to read**

One can see that most students rated themselves as proficient or exemplary in each of the categories. The analysis of their work supports the well documented findings from models of achievement motivation and behavior that indicate when people expect to do well, they tend to try hard, persist, and perform better (Pintrich & Schunk, 2002).

In addition to the self-assessment, some learners' comments also reflect the same sentiment. For example, Saloni expressed success in her ability to find her own answers. She writes:

Saloni's Journal entry from Phase II – Inquiry Stages:

- Success so far was that I found answers to my questions and learned lots of new things.

Ellis, a student who usually required a significant amount of direction to 'stay on track' with her task commented:

Ellis' Questionnaire from Phase III:

['it' refers to the intervention]

- It helped me because now I know I can do more then a teacher would tell me to do.
- It helped me because it was easier for me to understand this.
- it influenced me by telling me that I can do anything beteer if people don't tell me what to do!

Zareen exhibited belief in her capabilities with her confidence to help others learn:

- Zareen Questionnaire from Phase III:
- - Yes I did benefit from this way of learning because now I am happy that I know a lot of information about space and whenever someone has a question or needs help on space, I will always be prepared to help them or answer their question.

7.2.3 Independent engagement with text. Another interesting manifestation of will was evident in students' independent engagement and persistence with their text. In a class with predominately English language learners, I anticipated that students would voice complaints and/or show resistance to the amount of reading that formed the basis for this inquiry. I was very aware of the strong possibility that interacting with text may not have *'moved'* students yet alone sustain them in their learning processes. Although some students acknowledged that this way of learning was more work, with the exception of one student, the class did not adopt a negative view of inquiry reading. Learners exhibited positive affect when describing their relationship to the text and some communicated specific strategies they used to overcome difficulties. The following excerpts provide some insight:

Darren, Fatima, and Ava refer in different ways to the attention given to their work through the science journal and student/teacher conference which made them more accountable to read, re-read and verify what they learned through thinking, checking and explaining.

Darren's Journal entry from Phase II – Inquiry Stages:

- This affected how I learned in a good way, because if I read it and sloped it down on good copy paper without thinking or checking things over I would have got all of the answers wrong.
- This affected the way I think because if I had wrote everything down without checking it, it would all be wrong. But I checked it over and saved myself from making alot of mistakes.

Fatima's Questionnaire from Phase III:

- This helped me a lot, because when I take information from text and put it in my words it helps.
- This way of learning influenced my learning and thinking easy and I would love to learn like this helps me for my thinking. It makes it easy.

Ava's Interview Conducted in Phase III [Transcribed from video data recorded on March 12/09]:

> S: *This way was different – you're making up own questions. I learned more than term 1 because working in groups is a bit harder. I learned more working individually and read more. I read more to find*

information because could not just write anything down because had to explain what I learned [referring to conferencing with teacher]

Saloni and Riddhi expressed that reading made them more curious.

Saloni's Interview Conducted in Phase III[Transcribed from video data recorded on March 12/09]:

> S: *This way of learning made us more curious about space because we had to look at books and research to get an answer. In the traditional way I did whatever I was told. In term two my curiosity increased a lot. I was also arranging my notes very well instead of slapping them down.*

Vidya's Journal entry from Phase II – Inquiry Stages

1st Question

- I have been successful in my reading by highlighting, underling key words and re-reading all of the information. By doing this I will be able to understand better. Also I will be able to remember and learn information more easily. Also I answered all of the questions to the best of my abilities.
-

2nd Question

- I have been successful in my learning by rereading the text. Also I put my best effort in all of my work which means that I do my very best. This is how I have been successful in my learning.

Despite students' positive attitudes towards text, some did express difficulty with the science vocabulary. One of the difficult features of the language of school science is that science text contains technical words that usually do not occur in the context of everyday language communication. Science vocabulary is used to accurately communicate the specialized knowledge of science. For example, students expressed their experiences with this difficulty as follows:

Melody's Journal entry from Phase II – Inquiry Stages:

- Don't understand words
- Because I'm looking in the dictionary for what words mean
- Cant pronounce words
- See on dictionary to see how to pronounce a word

Nathan's Journal entry from Phase II – Inquiry Stages:

1st Question (source 1)

- The only difficulty I noticed having was the grammar. Some words that I didn't know like "equilibrium" and had to look them up. Otherwise it was quite easy.

Vidya Journal entry from Phase II – Inquiry Stage:

- Some difficulties I am having is that I don't understand some words in the text. This makes it hard for me to understand some parts of the text. Without understanding some words in the text, then I have difficulty understanding some parts of the text.

Hamna Journal entry from Phase II – Inquiry Stages:

- I am not having difficulties but sometimes in books the words are complicated to understand so I put it in my own words.

Saloni's Questionnaire entry from Phase II – Inquiry Stages:

- difficulty understanding some vocabulary

Nadine's Journal entry from Phase II – Inquiry Stages:

3rd Question

- for the first text I thought this text was very interesting informative and convincing. Many questions I had in my mind have been answered using this text and it has answered my research question in a very through and detailed manner. A small problem though was that just like I may have mentioned before, in this text there are words and certain concepts that had to do with the text that I had not learned about yet and this text they did not explain these concepts (like what a geomagnetic storm was?) and so I did not have a clear definition and that may have affected my understanding of the text in a negative fashion. For the second text I thought exactly the same thing I thought of the first text, the same problem did not occur though as much and so this text was a little more understandable than the last. Also this text explained all the parts of the text in brief ways that usually make sense fast.

Ava Journal entry from Phase II – Inquiry Stages:

- I had a bit of difficulty with the vocabulary words and some chemical words

Audrey's Journal entry from Phase II – Inquiry Stages:

- The difficulty I'm having is understanding the words in the text.
- Difficulties I am having is that I am having trouble understanding and pronouncing the words.

Riddhi describes the reading strategies she used to overcome this challenge. She describes reading the sentence without the word to glean meaning. She would then try to replace the word with a more common word to facilitate understanding. Her journal entry reads:

Riddhi's Journal entry from Phase II – Inquiry Stages:

- This way of learning influenced my thinking be being more curious and try to learn more about space, and try to apply it to other areas, example language art and I came up with a new strategy about if I don't know a word, I read the sentence without the word try to educate a vocab. That would make sense, read it over, and if it makes sense, I go with it and look in the glossary or dictionary and I am usually right and I use this strategy for other subjects.

- I have been successful in my learning by using a special strategies example like when I don't understand the vocabulary I changed the hard words to the vocabulary and I read it over what I understand then change the words and read it with my vocabulary and then put I in my own words
- I had difficulties understanding what is coma, so I read it again carefully and found out it is gas clouds.
- I have been successful in my learning by using different strategies to understand.

Riddhi expresses her success in this strategy since the meaning of her replacement word is synonymous with the original science vocabulary.

Although Riddhi deems her strategy a success, it is important to note that because science vocabulary is precisely used for the different domains of science, a reader cannot simply replace the word with one that is more common without the loss of semantic accuracy and technicality (Fang, 2006). Fang notes that even if science words are the focus of vocabulary and comprehension exercises, there can still be significant comprehension challenges especially when there is a heavy concentration of technical terms within a sentence.

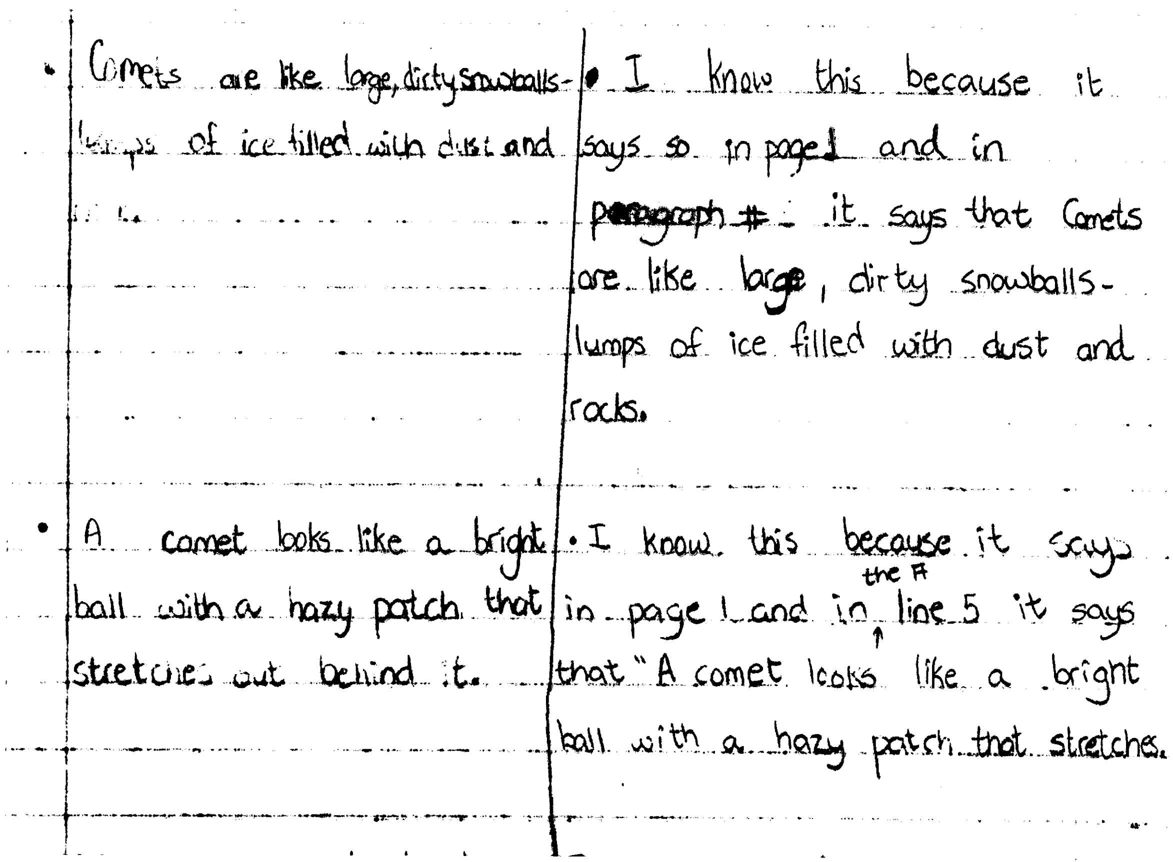
7.2.4 Summary. The data recorded in this section indicate the ways in which students' positive feelings, emotions and self-efficacy beliefs in this learning model sustained their will to learn as demonstrated by their persistence to learn. Of interest is that students' reflection data highlighting the affective dimensions of their learning appear to be aligned with the observations of researchers such as Linnenbrink and Pintrich (2002) who note that students' personal interest in a topic is often measured by students' reports of how much they "like" or "enjoy" a particular activity. This sample of student excerpts reflects the class' multiple and overlapping motivational pathways that support their will to learn and reinforces the notion that the affective dimension of learning, self efficacy and interest are not only a catalyst for learning but also a necessary condition for learning.

7.3 How Students Learned Science

7.3.1 Students' metacognitive reflections on their learning. In addition to their will to learn, students' *own* use of, what Rancière termed, 'necessary habits' (Chapter 2) is also interpreted as an expression of intellectual emancipation. In Chapter 2, I argue that for the context of this study, the 'necessary habits' (that which is the work of the body to bend to the necessary habits to compel the intelligence) could be interpreted as the skills and abilities that are required to be intellectually emancipated through text. That is the capacity to learn is supplemented by the will to learn and the development or use of specific skills and abilities. In the data, these 'necessary habits' appeared as a broad theme that I named metacognitive reflections on learning based on (1) students' awareness and articulation of specific skill they utilized and (2) the fact that these skills and abilities bear significant correlation (similarity) with what are commonly referred to in [Ontario school based practices] education as metacognitive strategies. In this model, students are obliged to use their intelligence to learn by themselves through comparison (word, sentence, and paragraph) and their response to the questions: *What do you see? What do you think about it?* and *What do you make of it?* (Rancière, 1991). I discovered that the students' science inquiry through text did yield responses to these questions and their conclusions (W*hat did you make of it?*) were formed based on their *own* verification of what they read. It was interesting to see the strategies that students applied during reading in order to verify what they learned. These strategies took the form of a) comparing different texts (what do you see?), (b) forming opinions of the authors and the information they provided, (c) students' use of background experiences (what do you think about it?), and (d) monitoring their understanding.

Learning through different texts. In the science journal where students documented 'what they learned' and 'how did they know it', I had anticipated that students would summarize an author's argument (proof from text) as evidence of what they learned. However, analysis determined that students additionally used copying and paraphrasing of the text to document how they knew a fact. They used this record to compare what different authors said. The following examples illustrate these strategies.

Students used copying strategies in various ways. Hamna used copying strategies throughout documenting the information with line, paragraph and page. The following is a sample (Figure 14).



• Comets are like large, dirty snowballs- lumps of ice filled with dust and	• I know this because it says so in page 1 and in paragraph #1 it says that Comets are like large, dirty snowballs- lumps of ice filled with dust and rocks.
• A comet looks like a bright ball with a hazy patch that stretches out behind it.	• I know this because it says in page 1 and in the # line 5 it says that "A comet looks like a bright ball with a hazy patch that stretches.

Figure 14. **Hamna's journal entry from Phase II – Inquiry Stages.**

Some students paraphrased what they read. For example, in the left column Samrin writes what he learned. In the right column, he paraphrased what the author wrote in order to verify the source of his knowledge (Figure 15).

Figure 15. Samrin's journal entry from Phase III – Inquiry Stages.

Other students like Andrea and Saloni used summarization. Andrea's sample illustrates that she summarized the text from the website (Figure 16).

[redacted]

***Figure 16.* Andrea's journal entry from Phase II – Inquiry Stages.**

Paraphrasing and summarizing are reading strategies that can indicate a student's level of understanding. When students paraphrase they translate text passages into their own words. At this grade level students typically rephrase or retell. Summarization requires students to synthesize what they have read by putting the information into their own words. The latter is a more advanced skill involving retelling, analyzing, evaluating, and inferring, thus leading to a deeper understanding.

In addition to summarization, Saloni also used many graphic texts to retrieve information (Figure 17).

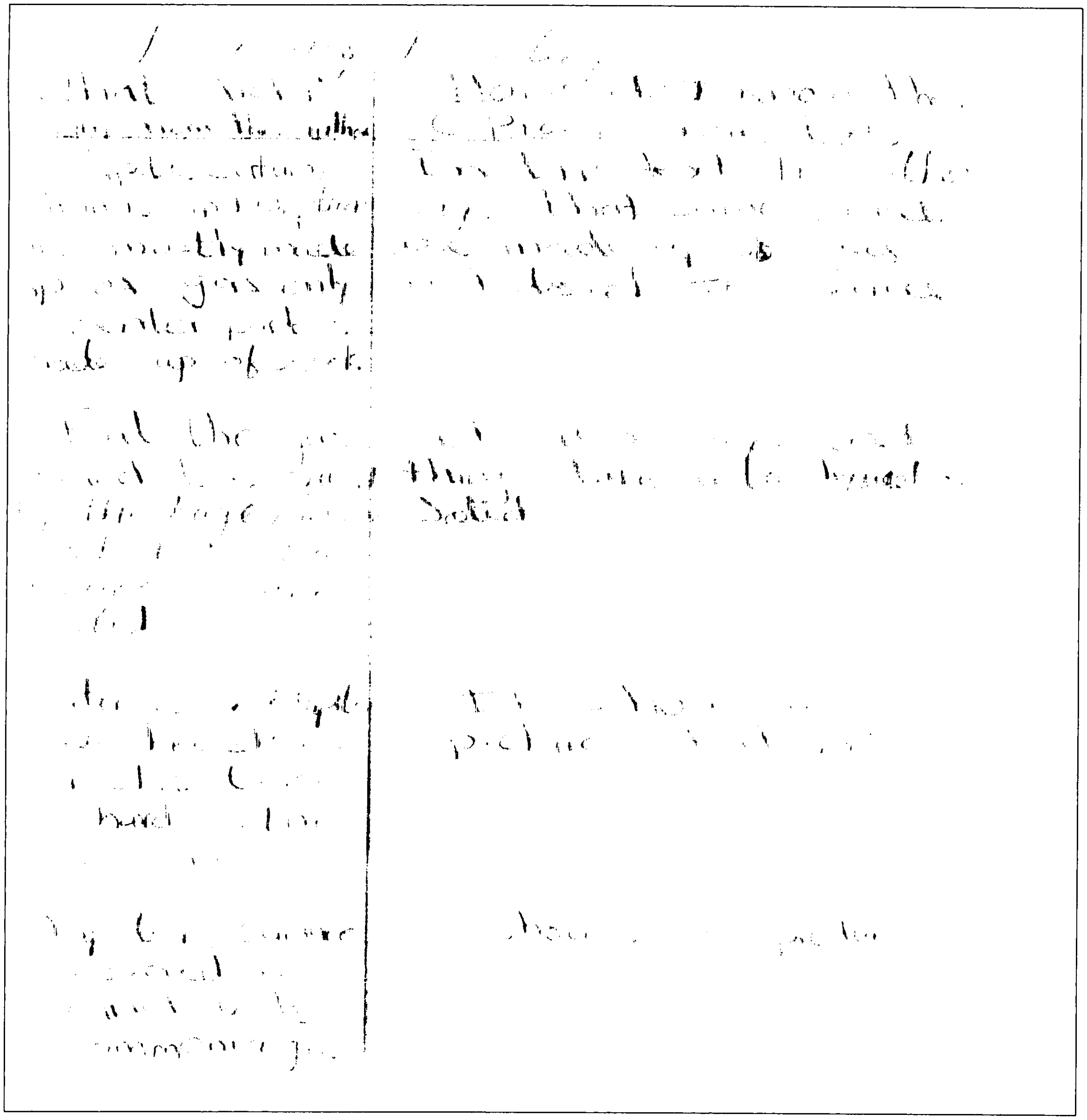


Figure 17. Saloni's journal entry from Phase II – Inquiry Stages.

Saloni's journal entries exemplify how students use pictures, photographs and the accompanying captions to extract meaning from text. Their use highlights the importance of graphic representation that provides complete explanations about the object or phenomenon depicted as well as the appropriate associations between the concept being presented and what can be seen in the picture or photograph in order to maximize the chances that readers will connect and interpret the text and graphic in the way expected by the author (Roth, Pozzer-Ardenghi, & Han, 2007).

In addition to documenting what they learned from an author, students did progress through their search by comparing facts and information presented by different authors. Students' defined one aspect of their success in learning around their ability to find 'proof' from the author and corroborating this information with other authors and sources. For example,

Zareen's Journal entry from Phase II – Inquiry Stages:
1st Question (2nd source)

- I am really successful because first of all I found the proof and very good explanation about what I wrote before *[referring to information from 1st source].*

Zareen's Journal entry from Phase II – Inquiry Stages:
1st Question (2nd source)

- This website gave me a wonderful explanation on some of the things I wrote before.
- I conclude that I am happy that I found all the explanation and proof from this website about what I wrote *[referring to information from 1st source].*

Hamna's Journal entry from Phase II – Inquiry Stages:

- The result is the info. In the book is very informative and answer is very simple to understand.
- *[referring to other source]* When I finished reading this book I got the exact same info. But in a different way.

Muhammad's Journal entry from Phase II – Inquiry Stages:
2nd Question (source 5)

- This *[information]* relates to the book called "Science Book" because it has the exact info but his *[referring to other author]* has a little more detail.

Mohammad's Journal entry from Phase II – Inquiry Stages:

- In book number 2 it says that the sun is made of super hot gasses which are helium and hydrogen. In book number one it says that the sun is make of super hot gasses which relates to book number 2 because they said the same thing. I also knew that the sun is the thing that makes life on Earth because of heat and light. In the book number 1 it says that the sun is the most important thing in the solar system and I knew that because without it there would be no life.

Opinions formulated about the authors

Students formed opinions about authors that were based on their perceptions of the validity and reliability of the information provided. For example,

Zareen's Journal entry from Phase II – Inquiry Stages:
1st Question (1st source)

- My conclusion is that I like the thoughts of the author because he has an amazing explanation about what he writes. He explains what it means and then he gives proof.

In comparing another author, Zareen concludes that the author's information is not reliable due to his failure to provide adequate proof. She indicates,

Zareen's Journal entry from Phase II – Inquiry Stages:
1st Question (3rd source)

- - I think the author is a bit wrong because he doesn't even have a proof of what he is saying and I am not satisfied with that.

The following excerpts from Nathan and Ava describe how they form opinions about the authors:

Nathan's Journal entry from Phase II – Inquiry Stages:

1st Question (source1)

- I thought that I was pleased to get my answer in full detail. I liked the explanation. I thought that the author did a lot work into the topic.

1st Question (source 2)

- I got the same answer as I did in my other book. This gave a little better explanation. Yet I understood both. I know that the Sun wasn't on fire but was "on radiation".

2nd Question (source 3)

- The difficulties that I'm having is not getting enough detail to clearly understand. I did get a clear answer but an example of lack of detail would be "when it contracts" He doesn't explain how it contracts! Also, he has difficult space grammar with no explanation!

Ava's Journal entry from Phase II – Inquiry Stages:

- This book was an O.K. book because the author in some parts was blabbering for nothing.
- I think the information was sometimes true and sometimes false. I think the author is confusing me with true and sometimes false info.

These comments indicate a level of engagement in reading by students that reflect not only thought about the content of what they read but how the information was communicated by the author. Their reflections seem to indicate active participation as they constructed meaning from text as opposed to a more passive stance towards the author and the text.

Prior experiences. Student comments also highlight how they access their prior experiences and background knowledge to make meaning from the text. For example, Zareen, Muhammad, Vidya, and Samrin write,

Zareen's Journal entry from Phase II – Inquiry Stages:

3rd Question (1st source)

- This is mostly what I saw on the Discovery channel and had a clue of this in my mind.

Zareen's Journal entry from Phase II – Inquiry Stages:

1st Question (3rd source)

- I think I saw a program related to what this author said and that program was wrong so I think this piece of information that I got is also wrong.

Muhammad's Journal entry from Phase II – Inquiry Stages:

1st Question (source 1)

- I think that one author and one book explained it very well. Information was accurate and logical
- As we saw in the Ontario Science Center, they found relative info. Also, in other books I've read, they show basically the same info.

Vidya's Journal entry from Phase II – Inquiry Stages:

1st Question

- After reading this text I can connect this passage to another reading from this book called Magic School Bus (Lost in the Solar System). This book is by an author called Juanna Cole. The connection I can make is that in my passage and this book it says that the farther away a planet is from the sun the colder the planet gets. But, the closer a planet is to the sun the hotter it is. This tells me that the temperature changes within planets by how close the planet is to the sun. That also means that the sun provides heat to the planets near it.

Samrin's Journal entry from Phase II – Inquiry Stages:

- The ideas relate because we watched the movie of moon it showed that how we reached the moon.

These examples illustrate how students manage science ideas through eliciting their prior knowledge and previous experiences. When students are helped to draw from previous experiences and prior knowledge, they can use this as a foundation for subsequent learning (Bransford, Brown, & Cocking, 2000). Furthermore, Moje and Hinchman (2004) have demonstrated that when connections are made between science and students' own backgrounds, everyday experiences, and interests, students are more likely to find value and meaning in their classroom science tasks and activities.

Monitoring understanding. Students monitored their understanding of the topic as they progress through the process of answering their questions. The following journal entries provide insight:

Zareen Journal entry from Phase II – Inquiry Stages:
3rd Question (1st source)

- I conclude that I like it and also learned a lot about things but I still need proof of my reading and still need a lot more information on it.

Vidya's Journal entry from Phase II – Inquiry Stages:
2nd Question

- I think that the text that I read really relates to my question. It helped me understand the different temperatures in planets and why the change. An example is that Mercury has a higher temperature than Earth because it is closer to the Sun.
- This text relates to a website I read. it was about the distance between each planet to the sun. that relates to my topic because the farther or longer distance away a planet is from the sun the more colder it gets and vice-versa. This tells me that is a true statement. This is what this website reminds me of.
- From my question "why does change within planets?" I conclude that the temperatures change within planets by how it is rotates around the sun. If a planet is a long distance from our hot sun, the planet's temperature will decrease. If the

planet rotates closer to the sun, the temperature increases. I learned this theory from this VERY interesting book called "Planets". The author of this book is Darrow Schecter. This book had tought me the distances from 1 planet to the sun. This helped me realize how far away a planet is from the sun and how less the temperature should be. This is my conclusion.

Nadine's Journal entry from Phase II – Inquiry Stages:
2nd Question

- I thought for the first website I thought that it had some understandable parts and that this text was very interesting and stated many facts I had not known. There was one part, however about the text that I did not understand. This was the part about the earth being tilted at 23 ½ degrees. I also thought that this text need a bit more detail. For example. When it said that "The moon creates tides that help animals during their breeding cycles" it did not say how they help, (the tides). For the second website I thought that some facts it stated were not really facts but guesses because what it stated did not happen yet.
- For the first and second text I did not understand a few parts because I have not learned about those parts yet. Other than that, I don't feel that I am having any other difficulties.
- For the first text I understood a lot of what had been said and since I have not known most of these facts I have learned something new. For the second text I don't think I have been successful in my learning since these facts might not really be true, I haven't learned anything.

Muhammad's Journal entry from Phase II – Inquiry Stages:
2nd Question (source 1)

- I am having a little difficulty just understanding some of the information (ex. Einstein's Theory of Relativity used in space travel)

Muhammad's Journal entry from Phase II – Inquiry Stages:

2nd Question (source 2)

- I can't say because worm holes have not exactly been proved real. I think it's true but, that's just my opinion.

Mai's Journal entry from Phase II – Inquiry Stages:

1st Question

- I am having difficulties understanding the mass of the density of a neutron star. I will watch more videos and read more about so I can understand. And I still don't really understand how protons and electrons combine into neutrons to create neutron stars. I am having difficulties in find more information about my answer.
- I have been successful in my learning in finding and solving my question. I know that the answer is a supernovae but I wanted to add more detail in the answer. I could not find much information about supernovaes. I think I was also successful in reading and understanding the author's information.

Samrin's Journal entry from Phase II – Inquiry Stages:

- I have been successful in my learning because when I was learning I double checked that everything is in details

Saloni's Journal entry from Phase II – Inquiry Stages:

- When I finished reading I thought that this info was unbelievable but I have to consult from another text.
- I actually never knew that stars are born or they had a life cycle like humans or at least close.
- I conclude that I have to consult from another text.

Darren's Journal entry from Phase II – Inquiry Stages:

- I think I gave good information except I think I could add more detail and information.

- This affected how I learned in a good way, because if I read it and sloped it down on good copy paper without thinking or checking things over I would have got all of the answers wrong.
- This effected the way I think because if I had wrote everything down without checking it, it would all be wrong. But I checked it over and saved myself from making alot of mistakes.

Nathan deciding when his journey ends comments,

Nathan's Journal entry from Phase II – Inquiry Stages:

2nd Question (source 1)

- I have been pretty successful getting a clear answer but I still don't have the details I need. I hope I can get more info from my next source.

Nathan identifies what he needs to do to understand. He writes:

Nathan's Journal entry from Phase II – Inquiry Stages:

2nd Question (source 3)

- When I finished reading I knew I'd have to get more info because I couldn't fully understand this info completely. I didn't know anything about thermonuclear reaction. I still go a straight answer. I still need more info!
- This doesn't relate to anything else because this is my first resource and I don't know anything about the birth of stars. The only thing I could relate this to is that I know stars use hydrogen for fuel which makes perfect sense in this case.
- I conclude I need more details.

2nd Question (source 4)

- I'm not having much difficulties, except for the fact that I haven't gotton a full answer to my question. I did not learn of the full process about the birth of a star.

2nd Question (source 5)

- I conclude I'm finished getting all the info I need. I have my answer.

- I'm not having any difficulties. Maybe a little more explanation. I still have the info and it's surpassed the criteria.
- I have been successful by getting my full answer. I have finished a step in my learning process.

As the excerpts show, students appeared to use and develop their ability to monitor their understanding while reading and were able to use different reading strategies to enhance their understanding. Metacognitive reading strategies such as clarifying confusion, asking questions when more information is required, and activating background knowledge to agree or disagree with an author's premise are part of the repertoire of strategies students used to construct meaning from their text.

Self awareness.–In this study, intellectual emancipation is described as the act of a student acting upon or executing their own intelligence while their will complies or follow the teacher's will to learn (Rancière, 1991). I was curious to see how student might articulate any awareness of accessing and applying their own intelligence to science learning in this way. In addition, evidence of this awareness would lend support to my interpretation and analysis of their behaviors of intellectual emancipation. I found that students articulated key aspects of the process of intellectual emancipation. Some conveyed growth in their ability to execute their intelligence, others communicated the freedom associated with its use and others communicated the positive learning outcomes of teaching themselves.

For example, Zareen and Nathan expressed their growth in their ability to use their intelligence with Zareen indicating that not only was she aware but surprised by her own development. She writes,

Zareen from Journal entry from Phase II – Inquiry Stages:
2nd Question (1st source)

- Actually it is surprising but now I am getting better and have no difficulty.

- I have been really successful in my learning by getting answers to my questions.

Nathan comments on his ability to put the pieces of his learning together through verifying information from different authors. He comments,

Nathan Journal entry from Phase II – Inquiry Stages:

2nd Question (source 5)

- I have been successful by still getting more info. The pattern that I'm seeing is that I'm getting extra detail from every book. I'm putting a puzzle together.

2nd Question (source 5)

- I conclude that the more sources I use the more detail I get. Right now I have a lot of detail and it was worth reading this book.

2nd Question (source 5)

- This learning process gives me more courage because every single thought of work is recorded into this so I know I've put a lot of effort. It works for me.

Nathan's Questionnaire from Phase III:

- This way of learning influenced my thinking in many different ways. One way is now I will organize all my information because it makes everything easier. I will also always check more than one source for information because this way of learning proves that not all are accurate. This is how it influence my thinking.

Nathan's and Zareen's responses offer some evidence to support the notion that students' confidence and independence grow throughout the inquiry stages as they become aware of their *own* intelligence and become more skilled at accessing it as an emancipated learner.

Other students commented directly on the freedom associated with executing their own intelligence. For example, Muhammad's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> S: *Traditionally we are given set questions to find set answer. In the new way there are many different possibilities to do it all by yourself - to find answers to your questions. Really unique and fun.*

Muhammad's Journal entry from Phase II – Inquiry Stages:

- This learning process is very good so far. It causes me to look at things in another way, think outside of the box.

Muhammad's Questionnaire from Phase III:

> - This way of learning caused me to think outside the box. Usually, teachers give you set questions to find set answers for. In this, we got to think of unique questions, research heavily and find detailed answers to.

Still others articulated their sense of intellectual emancipation by recognizing that they taught themselves and used their own intelligence to learn. They commented in various ways how exercising their ability positively influenced their learning. Their comments are as follows:

Riddhi's Interview Conducted in Phase III [Transcribed from video data recorded on March 12/09]:

> S: *I found this way interesting because you can do it yourself instead of the teacher teaching you. You're teaching yourself. After that you are showing what you learned the way you like it.*

Mohammed's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> S: *Finding your answer to the question is better than someone telling you. For example, you look up words in the dictionary instead of asking what it*

means. It is a good process to learn. Helps you remember because you're looking it up yourself.

Mohammed's Journal entry from Phase II – Inquiry Stages:

- Yes, this way of learning helped because by researching you would really actually get the answer and you will remember it, but if someone told me it wont be like burned in my brain. This relates to when Mrs. M told us t look up a word in a dictionary instead of someone telling you because if they did you will forget it.
- This was influenced what I learned because if the teacher was going to tell us the answer it wouldn't be good plus this question I made up so the teacher probably did not or would of not had the same question as I did.

Ekjot's Questionnaire from Phase III:

- This way of learning influence my thinking because I thought that the teacher gave us all the information but in this way of learning we have to research it ourselves
- This way of learning benefited my learning because it taught me to do stuff on my own to research and find information.
- This way of learning influence my other way of learning because we used to learn from a text book and the teacher taught us what to do but his way we have to do stuff on our own.

Hamna's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

S: *The new way was interesting. Before you just used to teach and we had to write the answers. The teacher use to give us the information. This way no one is teaching you. It helped my learning by organizing my thoughts. In 2nd term there was less help from teacher. We solved more by ourselves and can answer own questions. It changed my experience by giving me more confidence. I can see a difference in confidence and work from 1st question to 3rd question.*

Tagbir's Journal entry from Phase II – Inquiry Stages:

- This way of learning influence my thinking because in my thoughts in the traditional way, I'd just be like nah… this is boring, but in this way I thought it was more fun because we did the teaching.
- I think this will help me in the future because if I ever become a teacher I will know how to teach the students because of my childhood of Gr.6 and I will pass it on to the students.

Noura's Journal entry from Phase II – Inquiry Stages:

- Yes because it made me think science could be fun and interesting. I learned more because I did the research.
- Like I said, I learned more because I was doing the research and putting it all into my words helped too.

Three students expressed unease with the freedom associated with exercising their intellectual ability. For example, excerpts from Andrea's interview conducted in phase III [Transcribed from video data recorded on March 12/09], in discussion of her learning, she expresses her initial difficulty and lack of confidence to find the 'right answer'. Her reference to the 'right answer' refers to an answer she perceived the teacher would expect as opposed to finding a factually correct answer. I asked Andrea,

> T: Was it stressful? (Referring to the learning process)
> S: *No, not stressful. Having less teacher input a bit hard because didn't know if it was the right way to answer the question.*
>
> She came to resolve this by using her own ability by critically analyzing her answers as an objective observer to see if it made sense. She explains,
> S: *I judged by looking to see if the answer had enough detail. I would go back to the text to check the information.*

T: *Was it more work than other way? (Referring to the traditional way of learning)*

S: *Yes, I did more work.*

T: *In 1st term how would you know if your answer was correct?*

S: *I would check the answer against the teacher and teacher's notes.*

Andrea's journey towards intellectual emancipation is highlighted by contrasting her initial discomfort with her sentiments captured at the end of the interview in which she recognizes the role of her exercised ability in her learning. She comments,

Andrea's Interview Conducted in Phase III [Transcribed from video data recorded on March 12/09]:

S: *This way of learning science was really fun. We got to do it on our own with our own explaining.*

Although students experience with learning throughout the model of pedagogy may have varied from one point to another, the journey towards intellectual emancipation was not a positive overall experience for two students. For example, in her questionnaire, Melody exhibits a strong negative affect towards learning science in this context. She appears to be especially conflicted around the reflection questions whose purpose was to help students verify their search. She explains,

Melody's Questionnaire from Phase III:

- This way of science didn't help me because I felt the same way I would feel if I was doing science the regular way. Also because the way we did science this way it was annoying how I always had to repeat my reflections.

However, in her interview she expresses an intellectual struggle similar to Andrea and appears to have gained confidence as she recognized the worth of her intellectual ability. Referring to the learning processes she comments, Melody's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> *S: It was different because reflection questions helped me get my own ideas down instead of trying to get the right answer. You can choose what to include in your answer. Someone may say my answer is not correct because they would include different information in their answer. At first they were hard too because I was trying to get the reflection questions correct.* [What teacher expects] *I was trying to break the mold of that thinking. I was scared if not correct. I was still in 1st term thinking.*

Like Melody, Andrew was the only other student who expressed a dislike of the learning process in the model. Unlike the majority of the other students who flourished in this context and Melody, who although conflicted, found some value in the learning context, Andrew did not express any positive outcomes for his learning. In his questionnaire he responded,

Andrew Questionnaire from Phase III:

- No, I did not benefit from the learning because the other class went on to lots of different topics and we had to answer different questions.
- It did not influence my thinking

In his interview he commented,

Andrew's Interview Conducted in Phase III [Transcribed from video data recorded on March 12/09]:

> S: *This way was different. I didn't really like it because we had to research a lot. As a class we should have learned different things about space. In science we didn't get to anything – we didn't learn as much because we needed to research different kinds of things. We spent the entire time researching. Because we came up with our own questions we didn't cover range of topics as other classes did as a class.*

I was curious with Andrew's complaint which seemed to have two conflicting aspects. On the one hand he complained of too much research but on the other, he expressed that he was not exposed to a range of topics. I ask him,

T: What prevented you from coming up with other questions you had an interest in?

S: *I really wanted to concentrate on 1st question. Ran out of time for the others. [pause] Compared to the beginning of year in 1st term we did lots of projects. In 2nd term doing research didn't learn as much – didn't get to any real topics.*

Analysis of Andrew's answer to his only question did not reveal a commitment to his 'search' in that his answer did not reflect the depth or breadth of science understanding one would expect for the time committed to the question.

Andrew's responses may support the fact that too much choice could have some less adaptive qualities (Iyengar & Lepper, 2000, as cited in Pintrich, 2003). For example, "there may be developmental and individual factors such as students' knowledge, cognitive, and self-regulatory resources that can dramatically influence how students might cope with and react to different levels of choice and control" (Pintrich, 2003, p. 673).

Summary. Students monitored their own learning during reading by monitoring their understanding. However, I perceived a possible barrier to the depth of this process during my conferences with students. My observations led me to realize some of the problems that Phillips and Norris (2009) highlight in their examination of the language of school science and textbooks. They contend that although scientific journal articles deal in argument, science textbooks and trade books are primarily expository in nature. Drawing on the work of Myers (1992, 1997) Phillips and Norris point out that textbooks almost never "provide proof, present statements as accredited facts with no hedging, and use illustrations to picture rather than to provide argumentative functions" (p. 316). In the case of trade books, they cite Ford's (2005) study that determined most are non-fiction accounts of factual information and "scientific knowledge production was represented more as a procedure than as reasoning from evidence (p. 316). Although this point is not a focus of analysis, one can clearly see the influences of these deficiencies as students relate to their text.

Despite this, students did construct their own meaning while reading using the schema of their existing knowledge and personal background knowledge. In addition, as DiGisi and Yore (1992) indicate, the students did recognize what they knew about a topic, what they did not understand, and what they still needed to know to remediate discrepancies in their understanding. The results of the analysis of student data are supported by authors such as McTavish (2008) who contend that many metacognitive strategies are employed by proficient readers during reading to help them understand a text and Michalsky, Mevarech & Haibi, (2009) who assert "researchers have argued that to benefit from reading scientific texts, reading strategies and regulation of cognition appear to be crucial components in students' development of science literacy "(p. 364).

7.3.2 Conceptual understanding. In my role as a teacher-researcher, I was curious as to whether students would have the motivation to study science without the usual external motivating factors. As discussed, students were assessed for this science unit on their effort in the search for answers to their questions. My assumptions being that the effort to search and verify what they were learning would proportionally affect the quality of their answer. That is, the more attention and effort a student gives to the 'search' the greater the demonstration of science understanding in their answer. Students understood that their assessment would not be normative. I would not be comparing their work for a grade or the volume of work between students (i.e. the number of questions answered, the number of pages filled in their science journal, or the number of writing pieces they finished). They also understood that I would not be 'marking' the answers to their questions against a predetermined standardized sample answer. In my reflections, I was internally uneasy as a teacher with this posture. 'Best practices' for teaching promote explicitly informing students before a task, the criteria for which they would be assessed (what the teacher is looking for). In my field notes, I commented that I was somewhat vague myself at the beginning of the journey. As a researcher, I was reasonably confident in my understanding of Rancière's definition of emancipation as the act of a student acting upon or executing their own intelligence while their will complies or follows the teacher's will. However, I was less confident in anticipating what this would look like in a classroom setting and in the personal journeys of my students with their diverse personalities, learning styles, languages and cultures.

In this section, I turn my attention to student learning. Addressing the intellectual emancipation and learning separately is to acknowledge the fact that learning and emancipation are not always intertwined. Rancière comments, "Whoever emancipates doesn't have to worry about what the emancipated person learns. He will learn what he wants, nothing maybe. He will know he can learn because the same intelligence is at work in all the productions of the human mind, . . . "(Rancière, p. 18, 1991). As a teacher in the process of her own intellectual emancipation and with views of inquiry that place equal importance on the development of the student as on the learning of products (content), I might be adequately satisfied to primarily focus on the analysis of expressions of intellectual emancipation and the growth in students abilities in inquiry. In the previous section, there is evidence to support the assertion that students did learn something. Among other things, students learned about their ability to learn by themselves. They learned *how* to learn *for* the purpose of science inquiry through text. However, being in the process of my own intellectual emancipation still left aspects of my teaching self intellectually and professionally tethered to a system of accountability and testing. Therefore, I was also curious to know if students learned science content.

To this end, I identified two areas in this intervention that could reflect the extent to which students learned science content. They were the student generated questions and the writing pieces.

Student generated questions. As a teacher-researcher, I was curious to see if students would use this as an opportunity to exert the minimum amount of effort or in contrast, overcompensate by posing many questions followed by a shallow search for the answer? As the study progressed, I observed that even though students were researching their specific questions, they read more broadly than the specifics of the question to find their answer. As it turned out, their own self-generated questions afforded them the opportunity to learn the science content associated with the grade 6 curriculum (Table 10).

For example according to the Ontario Curriculum for Grade 6, the overall expectations for the unit include the following:

> By the end of Grade 6, students will –
>
> 1. Assess the impact of space exploration on society and the environment;
> 2. Investigate characteristics of the systems of which the earth is a part and the relationship between the earth, the sun, and the moon;
> 3. Demonstrate an understanding of components of the systems of which the earth is a part, and explain the phenomena that result from the movement of different bodies in space.
>
> (*The Ontario Curriculum grades 1 – 8: Science and Technology 2007*)

Table 9

Documents the Range of Student Generated Questions That Correspond to the Overall Expectations of the Unit

The 52 Student Questions Explored During the Implementation of the Model	
Overall Expectation: Assess the impact of space exploration on society and the environment	
Will humans live in space in the future? Why? When? What will it be like?	How does weather in outer space effect earth and everyday life on earth?
What are the effects of Sun gammas/gamma rays on our everyday life? How?	What was the first successful rocket to go to space?
Could human live on the moon as they live on Earth?	
Overall Expectation: Investigate characteristics of the systems of which the earth is a part and the relationship between the earth, the sun, and the moon	
What is Saturn's rings made of?	How did Uranus get rings?
What is a comet?	How does a star born and die?
How did Jupiter get its name?	Why are Neptune and Uranus blue and green
Who discovered Uranus?	Why is the Sun so hot and what is it made of?
How were all the planets discovered?	How are comets formed and made up of?
How does the moon get it's light?	Why do you think the tails grow longer and brighter as the comet moves along?
How did the Sun start to blaze fire?	Why does the moon shine?
How are stars made?	What are planets made up of?
What are stars?	Why does the moon change shape?

What are planets made from?	Do comets have tails and heads?
What are my favorite 6 planets made out of and what's the temperature?	How does a star born and die?
What is a galaxy?	Why are Neptune and Uranus blue and green
What is the moon made of?	What are Saturn's rings made of?
How does a Sun eclipse happen?	What are stars?
Why do temperatures change within the planets?	How did Neptune get its valley?
What are comets made from?	Who found Uranus?
How are stars born?	Who discovered the solar system?
Why is Mars red?	How hot is the Sun?
What is Pluto made from?	How did our universe form?
Was there ever oxygen on the moon?	Why is the great red spot red?
Overall Expectation: Demonstrate an understanding of components of the systems of which the earth is a part, and explain the phenomena that result from the movement of different bodies in space.	
What is a black hole?	Do stars have a lifecycle like humans?
What are the characteristics/attributes of a black hole in order for/to produce time travel?	What would happen to Earth if it went into a black hole?
Other Learning	
Is anyone or any life form out there?	What is the most common type of nuclear reaction on a neutron star?
Are aliens real?	Are people on Earth alone in the universe?
Is/was there any life on Mars?	

Through students sharing their knowledge and verifying what they learned, it was interesting to see, differences between the "volume (amount) of work" and the "effort" extended by students. That is, given the time frame, some students worked faster than others answering more questions. Although other students answered fewer questions, both groups exhibited a commitment to 'the search' and the learning process as a whole.

Apart from the legal requirements of curriculum content, all teachers have personal goals for the lessons they teach; the goals by which they set the criteria to judge their success or failure in teaching the subject matter. In my professional reflection as their science teacher, I found that the depth of content explored, learned and shared through student questions, met or exceed my own criteria for success.

With all the data collected, in phase III, I observed that the learning process positively impacted the learning of science for all but one student in the class. Through the student/teacher conferences, their science journals, written pieces, and sharing sessions with the class, students demonstrated not only their effort in the search for answers, but also their understanding of the 'Big Ideas' of the science unit.

Writing to communicate learning. Other evidence of students learning science concepts and ideas is further exhibited in students' writing pieces. The purpose of this work is to communicate an explanation of what was learned.

As students shared their writing pieces orally with the class they were given feedback regarding the effectiveness of their communication as well as their accuracy in answering the question. The teacher and classmates accomplished this through questioning and discussion as to whether their interpretations of the texts were commonly accepted by other learners and those in the science community. That is students' mis-interpretations were not accepted as being equally valid to an authors intended message.

In analyzing the different forms of student writing, I used my professional judgment to determine a student's understanding based on the extent to which they communicated misconceptions, that is, beliefs that are inconsistent with accepted scientific views. As well, I determined if students demonstrated enough knowledge about something for it to be valuable. From these criteria I determined whether students were working towards understanding, needing to revisit the inquiry for their question at a later time, or exhibited understanding appropriate for their age.

Assessment of students' science learning did not involve normative or summative judgments. Both assume end points in learning. To reflect the philosophical underpinnings of my action research, any feedback to students on their learning or 'assessment' of their writing was formative reflecting the fact that intellectual emancipation is a process, and the act of inquiry is never complete.

Table 11 reflects the analysis of student writing pieces for evidence of students learning science. The first column represents the different forms or categories of students writing pieces that were produced in phase two of the intervention. I selected to differentiate between different written styles to highlight the diversity of expressions that the students chose to use in their responses. For this reason, I organize the data by the writing style rather than students. Fifty-two different pieces of writing were collected. The second column indicates the number of pieces in each category. The 'checks' represent my judgment of the conceptual content of these different pieces of work. Of the 52 pieces of writing analyzed, 38 were judged as demonstrating an understanding of the science associated with their question.

Table 10
Analysis of Students' Writing Pieces

Categories of Written Work	Number of Writing Pieces In Each Category	Working Towards Understanding -Needs to Revisit	Demonstrates Understanding
E-Mail	1		√
Expository Book	5	√√	√√√
Expository Illustrated Book	9		√√√√√√√√√
Expository Paragraph	5	√√√√	√
Letter	12	√√√√	√√√√√√√√
Multi-paragraph Essay	7	√√	√√√√√
Narrative Book	1		√
Narrative Illustrated Book	1		√
Narrative Illustrated Story	1		√
Narrative Story	6	√	√√√√√
Planet Interview	2	√	√
Report	1		√
Script	1		√
Total	52	14	38

Table 11 shows that the majority of students demonstrated an age appropriate understanding of the concepts they learned.

An example of writing demonstrating age appropriate understanding is Audrey, in her illustrated children's book that addressed the questions, *how are stars born and how do stars die*. She communicated her understanding of content knowledge as expressed through the following excerpt from her book.

Excerpt from Audrey's children's book (Phase II):

> . . . *"O.K. class, today we will be learning about space," said Mr. Watts. "Any questions?" "I have a question Mr. Watts." "What is it Peter?" asks Mr. Watts." "How are stars born?" "Well, stars can come in all sizes and colours." Said Mr. Watts. "Blue stars are hotter and red ones are cooler. Stars are born out of clouds of hydrogen and helium" "Why? asked Peter. "Well without hydrogen and helium there is not star. Hydrogen joins together with helium" replied Mr. Watts. "When a new star is born, gravity pulls the star and gas together. When the gas compresses, the star begins to heat up. The gas starts to spin like a disk. After that, the star shines steadily."* ...

Students who were working towards understanding and who needed to revisit their learning exhibited different levels of misconceptions or misinterpretations of the author's communication. Although the inquiry stages required students to verify how they came to their knowledge or understanding, a reader's interpretation of a text is a complex endeavor that can still yield misconceptions. There is always the possibility that the author's intended message can be received in ways never imagined. The following excerpts on the same topic are provided as an illustration of differing levels of understanding exhibited in student writing:

Excerpt from Khalid's letter to parents in Phase II:

Dear parents,

Good afternoon, it is your son here. I am just writing this letter because I learned many things today about Mars and I want to share it with you. Do you know that there are worms or bugs on Mars that look exactly like earthly kind of worms?. . .

Excerpt from Zareen's children's book in Phase II:

[Written from the perspective of an alien]

Some aliens live on Mars. People from a planet called Earth think they can find us before the end of the century. They use some kind of radio telescope to find us

Excerpt from Muhammad's short story in Phase II:

[Written from the perspective of Mars personified]

Hello, I am Mars, the Red Planet. I am here to tell you about life on me…In 1976, the famous Viking mission to yours truly, sent back data of possible life on me…they sent a rover to collect a rock and send it back to Earth in a capsule. After it got back to Earth, they magnified it 1000 x and found images of bacteria in the Martian meteorite, kind of like the ones on Earth, except they looked like microscopic maggots to the eye, contained in it (the rock). Then, to go further, they put it under high magnification and found that other parts of the rock showed some more maggots and also orange "rosettes", which were about 5x the diameter a human hair, that's tiny! These "alien rosettes" were made of calcarbonate, the material the seashells are made of. To crack down ever further on the mystery of the rosettes, they operated NASA's ultimate magnification device, the SEM (Scanning Electron Microscope)… So, yes. The only type of life on me is microbial life. No humanoid aliens. Speaking of which, guess what NASA found on me? An alien! HA HA HA HA HA!!! Yeah, right! What complete id—ots! What they thought was an alien was actually just a blurry detail of a big rock in a photo…So, now you know. Bye!

Muhammad's writing piece would have contained similar misconceptions as the first two examples. However, during student /teacher conferencing, prompted by the reflection questions, he was motivated to continue his search and go back to his text and verify through other authors his information. Although Khalid and Zareen, determined after their conferences that their search was complete, and went on to write what they learned, they did not continue with their misconceptions for long. It was addressed when they shared what they learned with the class. Other students who had read the text and Muhammad who had personal experience with the same misconception challenged Khalid and Zareen to prove their understanding from evidence in the text. This exercise was enough for both students to realize their error. This scenario exemplifies the ways in which misconceptions were addressed throughout the model.

Student's non-use of their first language. I initially perceived students' non-use of their first language as an unsuccessful outcome of the experiment. From early in my observations I noted that there were no students who used their first language in their science journals. In phase one of the model, we discussed students' choice to use their L1 for learning as part of an equal learning environment. Since I anticipated the use of students' L1 as an intellectual resource, the fact that no student chose to use it was considered by me to be an unsuccessful outcome. Although curious, I did not want to ask students for fear of influencing their decision. By asking the question I felt that it might indicate bias towards an expectation that they should use their L1. By not asking questions around language use, I wanted to preserve and respect their natural learning preferences.

I decided to wait until the end of the study during student interviews to ask them directly. Their responses and discussions around L1 use indicated that some students did use their L1 but not in the way that I expected. Students did not write in their L1. A primary impediment to students using their L1 in this manner was the fact that although they spoke a first language they did not learn the language in its written form. From the interview data students expressed that they did not learn to write their first language for a variety of reasons that ranged from the fact that schooling in their country of origin was in English to a lack of practice. Although there was no evidence in students' science journals of L1 use, student interviews revealed that some English language learners used a variety of complex and internal cognitive strategies to elicit meaning from text. The following excerpts from student interviews reflect some of these strategies:

Riddhi's Interview Conducted in Phase III [Transcribed from video data recorded on March 12/09]:

> S: *Math and science is easier to explain it in my head in my own language than writing it down in English. If I don't understand I break sentences down and take English meanings of ones I don't understand then break them down into my language. I repeat in either language.*

Sushmitha's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> S: *The learning process made me think in my own language. I use my language in science a lot if the book is hard to understand.*

Melody's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> *S: I use both languages in my head. My dad helps me in Serbian. For hard thinking questions I use English because I'm better in English. Less deep thinking questions my head is thinking in Serbian. Language, math, and science is hard to translate words in Serbian.*

Navneet's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> *S: I use my first language by turning English words into Gurdrati. It helps me to think through idea. I like to learn science in English. Science*

vocabulary is harder to translate into my language so I think in English. In math I use my language for numbers.

Zareen's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> S: *I read words in English then break it down and translate into my own language. Science vocabulary is hard to convert. Like I don't know the word for microscope. But for thinking thoughts in science it helps.*

Muhammad's Interview Conducted in Phase III [Transcribed from video data recorded on March 10/09]:

> S: *I speak Gujarati at home. When faced with difficult questions I think in Gurdrati because I'm use to thinking in it at home. I translate questions in Gurdrati and write answer in my mind in Gujarati then translate to English then on to paper.*

Saloni and Ellis used their L1 in their writing drafts.

Saloni [Transcribed from video data recorded on March 12/09 (Phase III interview)] explained how she writes a draft copy in English then asks her mom to re-write it in Hindi. Her mother would read every sentence out loud to her to see it if makes sense. She explained how hearing the Hindi helps her think ideas through. When I asked her why she did not include the drafts in her journal, she commented that the drafts were very rough so she did not want to include them.

This sentiment is similar to Ellis who indicated in her interview that she did not include her drafts of writing in her first language for fear that the I would not understand (for grading purposes). She was fearful that it would be seen as negative or too different.

Although there are calls for L1 to be seen and used as a resource for learning in schools, how it is supported and used as a resource is uniquely different for each setting and group of students. One reason for this difference is reflected in the literature on mother tongue acquisition and maintenance. Parents and primary caregivers have the strongest influence on a child's first language acquisition. Their attitude, goals, and behaviors towards L1 development influences the child's developing language skills, language socialization, perceptions of the value of L1 and its maintenance (Gardner & Lambert, 1972 as cited in Ball, 2010). Most minority language parents want their children to succeed in school, and the broader society and also want their children to learn L1 and be proud of their cultural heritage. These dual language goals tend to act more on promoting second language learning than on L1 learning. This behavior in turn affects children's dual language behaviors: they sense that the home language is less important, resulting in the weakening of L1 in favor of L2 ((Ball, 2010) p. 16). Cultural community groups and language policies in school boards also influence the degree to which one language is favored over another.

7.3.3 Summary. These comments illustrate how a student's first language, in addition to English, provides a unique resource to construct meaning. However, their comments also point to the fact that the language of school science contains technical words that are not often used in their everyday informal speech. The technical terms are important for accurately conveying the specialized knowledge of science and explaining scientific concepts (Fang, 2006). Yore and Treagust (2006) note that learning science not only parallels learning a language, but also involves border-crossing between languages in what they term as the three-language problem—home language, instructional language, and science language. They contend that it is important for the first language of students to be explicitly considered in science classrooms and in teaching and learning environments where a different language of instruction and unique science language are involved. The authors propose that understanding the three-language issue involving students' first language, related beliefs, values, and thinking is helpful in the facilitation of cultural–linguistic transitions to the language of instruction and science language (Wang, Wang, Tai, & Chen, 2010).

However, the experiences of the students in this study support work by Olson and Land (2007) who challenge the perception that the skills needed by English language learners to be successful analytical readers are not within their reach. Evidence presented suggests that to a certain extent, as students exercised their autonomy and independence during the inquiry reading stage of the model, they used a variety of cognitive and metacognitive strategies. Olson and Land believe that teachers can learn to engage all students including English language learners in higher level thinking and discussion about texts through not only direct strategy instruction but also in creating opportunities for students to practice and apply the strategies through teacher coaching and feedback. As in the case of this study, direct strategy instruction was not employed, rather the student/teacher relationship placed different demands on how students accessed their intelligence for learning.

7.4 The Ignorant Schoolmaster

As stated, I chose to focus my analysis of the data for student behavior and expressions of their perceptions of learning that could reflect evidence of a move towards 'intellectual emancipation'. In so doing, I proposed that if evidence was found then I could infer that I had experienced some success in my own movement towards 'intellectual emancipation', that is, a pedagogical change in my sphere of influence not by replicating the conditions of Jacotot's circumstances, but by becoming an "ignorant schoolmaster" and creating the conditions for intellectual emancipation in my own classroom. Throughout this inquiry, I have grappled with what it means to be "ignorant." From a Rancerien perspective, there are perhaps relative degrees of ignorance, the most obvious being a teacher who teaches what they do not know. In this inquiry, I could not honestly claim this position. Even though I did not know where student's questions may lead them, and I do not purport to know all there is about Earth and Space Science, I do have a base of knowledge in this area from my own education and teaching experience with this grade level.

However, Rancière proposes other degrees of "ignorance," one being not faking ignorance to provoke knowledge but being the "cause of knowledge" for students without actually transmitting any knowledge (Chapter 2.21). That is, being a *will* that instructs the student to activate the capability that they already possess. In another degree of "ignorance" is refusing the knowledge of inequality by rejecting the premise that it is necessary to begin with inequality in order to reduce inequality. Through my encounter with Rancière, and my journey through the experiment, my "ignorance" might be seen achieved in the last two domains. The study was conceived from choosing to refuse the knowledge of inequality, which made its implementation a "political act" (Chapter 2.32). The interruption to the police order (Chapter 2.32) was manifested in the redefining of the teacher-student relationship, non-transmission of content in the traditional teaching method, the non differentiation of learning experiences for English language learners (same expectations for all students and choice of text), and the decision to not assess learning on the traditional criterion.

To say this does not mean that I do not recognize and acknowledge that I am not free from the learned and internalized oppressive practices that accompany my institutional role as a teacher. My encounter with Rancière inspired me to make the conscious decision to unlearn. In fact, coming to this place of ignorance *was* and *is* an ongoing process where mistakes are made along the way but yet positively impacts my practice and positively impacted the science learning experiences for my students. My study design and model outlined in the previous chapters were steps in this process. By re-defining the teacher-student relationship around intellectual equality, the students and I were arguably able to move from a more teacher-centered classroom and break the cycle of explication, which I felt perpetuated "intellectual helplessness". Students were re-awakened to their ability to exercise their own intelligence. They developed a sense of liberation as they gained confidence in their own abilities and shifted from a general "*I can't do it*" attitude to an "*I can do it*" attitude. Witnessing their success buoyed my confidence in my role as facilitator and my practice became less stultifying. In my study, the desire to be the ignorant schoolmaster was not an attempt at re-defining my pedagogy for utopian moments of equality and democracy. Instead, I entered into this inquiry acknowledging the power structures in schooling and society (of which I am a part) with the intent to interrupt these existing power relations in my classroom to create the environment for intellectual emancipation in students' inquiry learning in science.

CHAPTER EIGHT

DISCUSSION AND CONCLUSION

8.1 Introduction

My motivation for this study started with my reflections *in* and *on* my practice. My encounter with Rancière's radical philosophical ideology in *The Ignorant Schoolmaster* was *the* critical incident that impacted my personal and professional learning. Rancière's work provided an alternative lens through which to interpret my experiences in the classroom and with the structures of schooling as a whole. This new 'view' inspired me to examine practices in science education and my teaching that I believed to be stultifying to students. These practices outlined in the problematic (Chapter 1) include: a) an under-emphasis on the fundamental sense of science literacy and b) an overemphasis on hands-on practices of inquiry learning in science.

In *The Ignorant Schoolmaster,* I found points of interest and similarity in Jacotot's teaching context (Jacotot, his students and language) and my teaching context with English language learners. This, as well as his focus on text, prompted me to interpret elements of Rancière's work through an action research study with the aim to gain greater insight into my own teaching and students' learning in the science classroom. I evaluated the intervention by observing and describing any influence the intervention may have had on students' learning experiences, specifically movement towards intellectual emancipation through the use of reading as a form of science inquiry. In this chapter, I summarize the significance of the study and discuss the implications for future practices and pedagogy in science education.

The final remarks of the dissertation are organized around the three initial research questions that guided this study. In discussing the model that emerged from my action research, I aim to contribute a unique perspective in the area of science inquiry within the context of a multicultural, multilingual elementary classroom; one that I hope provides fresh insights into curricular and classroom practices that can be built upon or be used to inform other theoretical frameworks in science education.

Research Question One:

How did my practice respond to Rancière's notion of intellectual emancipation?

What model of practice emerged?

My response to Rancière's notion of intellectual emancipation changed my practice and resulted in a model of pedagogy that emerged from my action research. The model uses the practice of reading as a form of science inquiry to foster intellectual emancipation in students (Figure 18). The process for translating Rancière's theoretical vision into a practical reality was to start by setting the context for a different way of teaching and learning by re-negotiating with students, the teaching and learning paradigm. This was a move towards emancipatory practices. This move required me and the class to re-conceive the intellectual order of the classroom. In a practical sense, this meant reframing the student/teacher relationship, identity, and *ways of doing* in the science classroom. As science learners, moving towards intellectual emancipation meant *accepting* to work within a student/teacher relationship that was different from what originally existed and was known. The shift towards emancipatory practices required me to think differently and act outside the norms of traditional teaching. That is, to start from the presumption of 'equality of intelligence' by expressing my confidence in all students' ability to inquire independently and require students to assume more responsibility for their learning than previously experienced.

Re-orienting the class to a different way of learning was necessary to collectively engage students. Therefore, I taught four lessons that offered an opportunity to facilitate discussions on teaching and learning and explore the concept of intellectual equality in the classroom. These four lessons I call ***The 'Orientation and Exploration of Concepts of Emancipation' phase*** **(see Figure 18).**

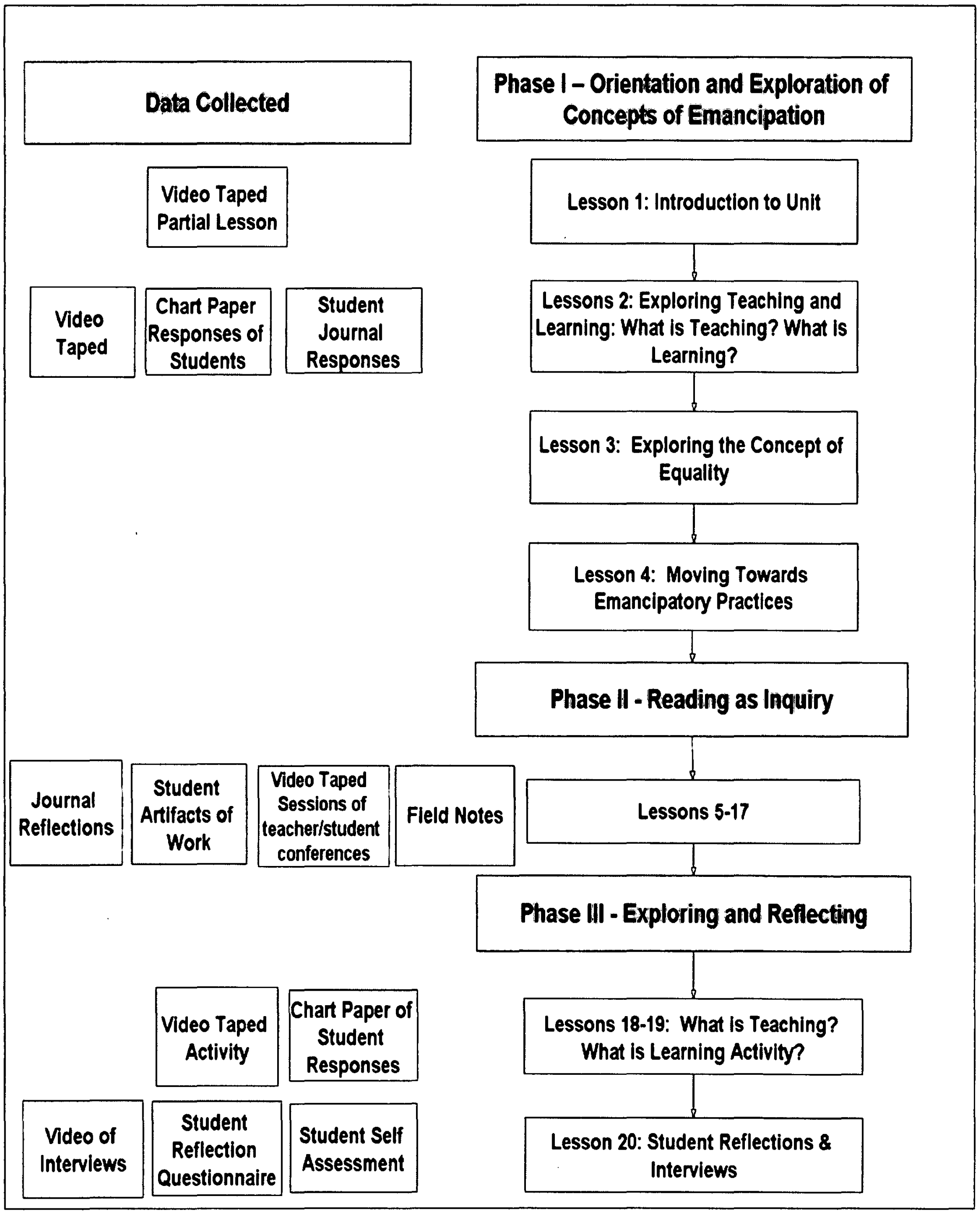


Figure 18. **Phases for the Emergent Model of Emancipatory Pedagogy.**

In lesson 1, I facilitated a class discussion recollecting what was learned and remembered from a class field trip at the end of the first term to the Ontario Science Centre where students watched an IMAX movie and participated in a demonstration workshop on Mars exploration. Lesson 2, I attempted to start to re-negotiate the pedagogical paradigm for teaching and learning in the science classroom by exploring, from the students perspective, teaching and learning. This was done through a combination of large, small, and individual reflective group activities (Chapter 6.2). Analysis of students' reflections (Tables 6, 7) indicated that they consistently wrote about learning situations where tools or hands on experiments were used. The responses also ranged from describing the benefits of learning science outside to learn about the environment to learning indoors with no distractions. In the subsequent classes, (Lesson 3 & 4) we explored the concept of intellectual equality through the telling of Jacotot's story (Chapter 6.2). I further explained the idea of equality of intelligence in the context of the classroom learning environment. In answer to student questions, I talked about equal intelligence as being about the equal ability to learn and that we were all equal in this respect. We discussed how this type of equality does not necessarily translate to what we do, the money we have, or our status within the community. I knew that the journey towards my intellectual emancipation involved a shift in power relations where I saw my students as intellectually equal to me. However, I realized that part of my teacher-self was not so willing to give up the 'old master' (Chapter 6.2).

Posing questions about equality to the class led to discussions about school and report cards. Students initiated the conversation about how a person's will or motivation is the key to learning and cited several personal examples of when they had the will to learn something and when they lacked the will and motivation to learn something else. They also discussed that what a teacher values is also a factor in learning.

Phase II, ***'Reading as Inquiry'***, is a response influenced by the problematic (Chapter 1.4). This phase consisted of thirteen lessons in which three stages of interaction with science texts emerged (Figure 19).

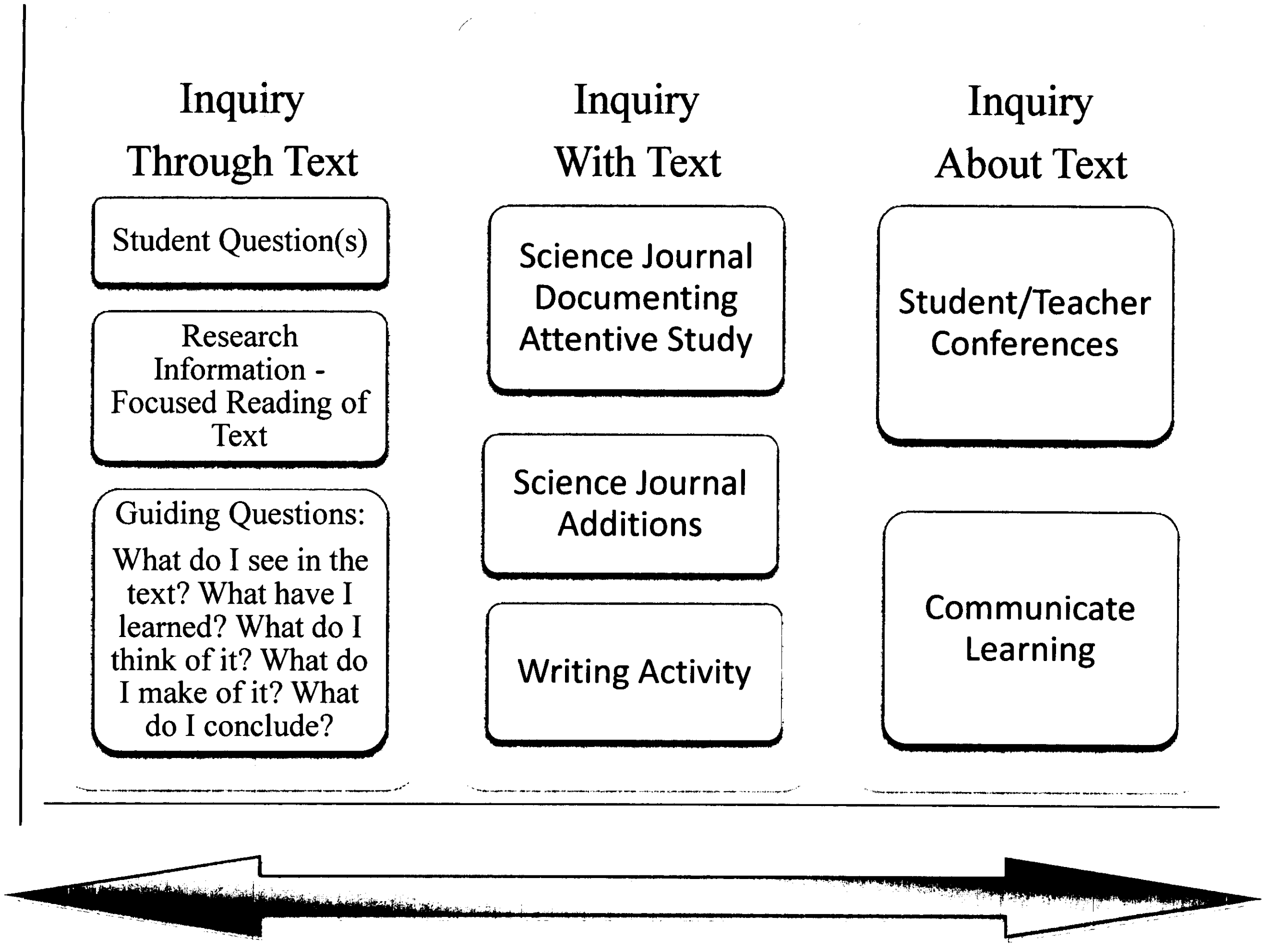


Figure 19. **Reading as Inquiry (Iterative Stages of Interactions with Text).**

Inquiry through text. This stage promoted the independent reading of science texts and included: 1) students determining their own inquiry questions within the topic of study, 2) choosing their own informational science text to research their inquiry and 3) reading the text with Rancière's guiding questions in mind.

Through purposeful conversation as they were reading, students were excited to share what they learned with other students. They also felt comfortable expressing any difficulties they had finding information to address their questions. As a result, students willingly shared their text resources throughout the term. The classroom dynamic still involved a sociocultural aspect of learning between students in terms of shared literacy experiences.

Inquiry with text. The second stage is characterized by 1) students documenting what they learned and reflecting on their learning in their science journals and 2) communicating what they learned through a writing piece. Once students determined that they satisfactorily answered their question they chose a writing form to communicate what they learned. Students chose to represent their work in a variety of forms from reports to creative writing pieces.

Inquiry about text. Inquiry About Text, the third stage of phase II, formally engages students with their teacher and peers. Students have a further opportunity to process what they learned and determine the validity of their conclusions as they communicate what they know. In this stage, this is done through 1) student/teacher conferences and 2) sharing their writing pieces with peers.

Students communicated what they learned by sharing their writing pieces either with me in the student/teacher conference or with the class and members of the larger community. Several students sent their work by email for feedback from fathers or other relatives who were abroad. The positive feedback and reinforcement of their effort was a very powerful motivating factor to continue their learning.

Research Question Two:

What are the effects of these changes for student learning?

In what ways do students demonstrate, or not, their intellectual emancipation?

How do students learn science concepts?

In this study, I analyzed student reflections *on* and *of* their learning as expressed in their own words to serve as useful markers of how intellectual emancipation might or might not be expressed. I used the vocabulary of the classroom and the words of the students to give a sense of reality to the data I collected at different points in time during the intervention. In chapters 6 and 7 I aimed to clearly and comprehensively present the data in the context of the classroom interactions and in its original form in order for the reader to clearly trace my interpretation and conclusions.

Given this consideration, I believe the results of the study and the interpretation of the results add to the discourse of emancipation, inquiry, and learning science. Two major themes arose from my analysis of the data (Figure 20): (1) evidence of students' will to learn, and (2) how students learn science.

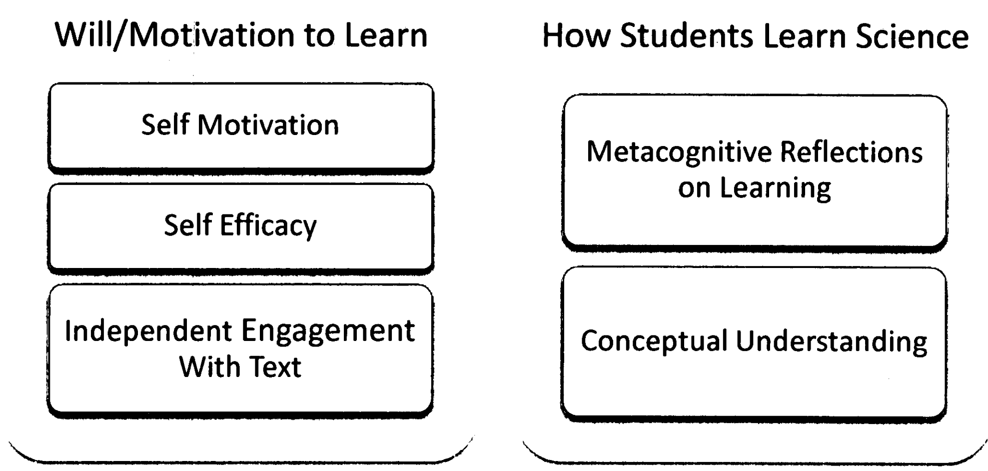


Figure 20. **Major themes that emerged from the data.**

Chapter 7 used the language of social cognition to discuss the expressions of will. Even though Rancière does not discuss or conceptualize a student's will to learn using these terms, the language of this field helped me to bridge between Rancière's lexicon and the more contemporary terminology associated with education today. This is in a similar manner to Rancière himself who commented on the 'strange' idiom he used in *The Ignorant School Master*. He stated, I used "an idiom in between the language of Jacotot and the language of our contemporaries. The language of Jacotot is not the one used today to discuss issues of education. His lexicon is not the lexicon that is now used" (Rancière, 2008, p. 174).

Students' Will/Motivation to Learn. My data analysis revealed indicators of will that emerged as self- motivation, self-efficacy, and independent engagement with text. The data supported that expecting students to use their ability to learn by themselves and responding to them accordingly through the philosophical framework of the model, resulted in students acting in response with the belief that they were capable of performing and learning in this new context. For example, their self-efficacy is reflected in the Research Process Rubric in which most students rated themselves as proficient or exemplary in each of the categories (research question, selection of sources, note-taking, organization) (Chapter 7.2). In the data collected, students revealed several reasons why this process of learning science was valuable and personally relevant to them (Chapter 7.2). The belief in their control was a reflection of their individual control to choose for themselves, the number of questions posed, the number of authors consulted for each question and when their learning journey ended for each inquiry.

Despite student's perceptions that this learning experience was more work and their challenges with vocabulary, the students, most of whom were English language learners, confirmed their motivation to do well and succeed in their learning (Chapter 7.2). Student responses reflect the multiple and overlapping motivational pathways that dictated their will to learn. For the students as a whole, their will to learn science in this context appeared to be intrinsically motivated and sustained through their self-efficacy beliefs. In addition, they were also motivated to persist and try hard to achieve because of their personal interest, value beliefs, and sense of control over their learning (Chapter 7.2).

How Students Learn Science. In order to verify what they learned students displayed a variety of metacognitive strategies during reading. These strategies took the form of a) comparing different texts (*what do you see?*), b) forming opinions of the authors and the information they provided, c) students' use of background experiences (*what do you think about it?*), and d) monitoring their understanding (Chapter 7.3).

Students primarily used copying, paraphrasing and summarization of the text to document how they knew a concept (*what do you see?*). In addition to documenting what they learned from an author, students compared facts and information presented by different authors. Students defined one aspect of their success in learning around their ability to find "proof" from the author and corroborate the information with other authors and sources. Student comments indicate a level of engagement in their reading, as they not only thought about the content of what they read but how the author communicated the information. Their reflections seem to indicate active participation as they constructed meaning from text (Chapter 7.3).

Analysis of the data also illustrates how students managed science ideas through eliciting their prior knowledge and previous experiences in the world and with other text. As well, the data showed students monitored their own learning during reading by monitoring their understanding. Excerpts show students appeared to use and develop their ability to monitor their understanding while reading and were able to use different reading strategies to enhance their understanding (Chapter 7.3).

Over the years a body of research (ex. Avermann & Moore, 1991; Fang & Wei, 2010) supports the use of explicit instruction on the use of metacognitive strategies that students can employ while reading. Although explicit instruction did not occur in the most typical methods such as, discussion, modeling, or student practice with gradual release of responsibility, metacognitive guidance and direction was provided through Rancière's taxonomy of questions throughout the reading inquiry stages to aid students in critically reading the text. The purpose of the reflective questions in the students' science journal was to keep students committed to their search for knowledge and to always verify their understanding of what they learned. The questions and journal set up was a visual organization tool that provided opportunities for students to apply reading and metacognitive strategies to their learning. As discussed (Chapter 5), this educational intervention focused on providing the opportunity for students to engage in the reading of different texts (of their selection) through which they had an opportunity to apply their own repertoire of reading strategies as they learned through the inquiry process. As

Valencia and Pearson (1987) note (in Yore, Bisanz, & Hand, 2003), the interactive-constructive view of reading "de-emphasizes the notion that progress toward expert reading is the aggregation of component skills. Instead, it suggests that at all levels of sophistication, from kindergarten to research scientist, readers use available resources (e.g., text, prior knowledge, environmental clues, and potential helpers) to make sense of text" (p. 698).

In this study, intellectual emancipation is described as the act of a student acting upon or executing their own intelligence while their will complies or follows the teacher's will to learn (Rancière, 1991). Awareness of their ability to learn by themselves would lend support to my interpretation and analysis of their experiences of intellectual emancipation. I found that this was articulated when some students spoke of growth in their ability to execute their intelligence; others their freedom associated with using their intellectual abilities; and those who communicated the positive learning outcomes of teaching themselves (Chapter 7.3).

In chapter 7, I teased out the discussion of learning from the discussion of intellectual emancipation in order to focus specifically on the learning of science content. As teacher-researcher, I was aware of the uniqueness and the shared commonalities of each construct. As a researcher and teacher, I was interested in the intervention and the possibilities that it afforded me to gain further insight and understanding of intellectual emancipation in my students. However, as a teacher, I was also responsible for ensuring that science learning occurred. To this end I identified two areas that could reflect the extent to which students learned science content. They were the student generated questions and the writing pieces.

I observed that even though students were researching their specific questions, they read more broadly than the specifics of the question to find their answer. This afforded them the opportunity to learn the science content associated with the grade 6 curriculum (Table 10).

Other evidence of students learning science concepts and ideas is further exhibited in students' writing pieces in which the purpose is to communicate an explanation of what was learned. To reflect the philosophical underpinnings of my action research, any feedback to students on their learning or 'assessment' of their writing was formative, reflecting the fact that intellectual emancipation is a process, and the act of inquiry is never complete (Chapter 7). Table 11 shows that the majority of students demonstrated an age appropriate understanding of the concepts they learned.

In this study students primarily used creative forms of writing to communicate their science content learning. In the science education literature, there are two dominant schools of thought regarding the promotion of student writing in science. One approach is aligned with the idea of learning the structure of a language system. The focus is on students learning to understand and reproduce the traditional written discourses of the science community. This is accomplished through strategies such as, analysis of the linguistic features of text, co-writing genres with the teacher, and explicit teacher-directed focus on key textual function and form relationships and their rationale. The second approach, which was used in this study, promotes the use of diverse writing types that include both formal and informal types to acquire science literacy and positive attitudes towards scientific inquiry (Hand et al., 2003). This perspective views everyday language as a valuable medium for learning science. This approach believes:

> . . . learners need to be able to connect learning the new literacy of science to the other literacies of their community and culture. From this perspective, a communicative focus is favoured, emphasizing diverse purposes and readerships for texts, recognition of readers' expectations and needs, and the value of writing cycle entailing reader feedback on student drafting. (Hand et al., 2003, p. 613)

Both approaches have been shown to yield positive results in developing students' science literacy in both the fundamental and derived senses of science literacy (Hand et al., 2003).

Some students experienced learning through the use of their first language. Because I did not see students using their first language in their science journals or their writing I perceived the non-use as an unsuccessful outcome of the intervention.

However, interviews revealed that some students used a variety of complex and internal cognitive strategies to elicit meaning from text using their first language (L1). These strategies included translation in their head and the use of L1 in draft writing. One student talked about her mother's support with L1 in the draft writing process as she used her L1 to help her think. The two students who used their L1 in some form of draft writing saw some negative association with including them with their learning resources in the class. Most English language learners in the class did not use their L1 because they did not learn the language in its written form for a variety of reasons that ranged from the fact that schooling in their country of origin was in English to a lack of practice (Chapter 7.3).

Some students experienced challenges in their learning related to science vocabulary. Although students had a positive attitude towards text, they expressed difficulty with some technical words and their meaning. Students used different reading strategies to facilitate their understanding. Evidence suggests that two students experienced challenges in their learning from their dislike of the model (Chapter 7.3). Although the experience of learning throughout the model of pedagogy may vary from one point to another, only two out of twenty-seven openly expressed that they disliked learning with the model when asked in the interview. One student was conflicted regarding the reflection questions and was annoyed at having to answer them. However, in her final interview she expressed their benefit in helping her get her own ideas down instead of trying to get the 'right' answer. The other student felt that he did not benefit since there was too much emphasis on research and he was not exposed to a range of topics. Overall, students were positive about the model (Chapter 7.3).

Research Question Three:

What are the effects of these changes for teaching and learning?

In what ways do these changes influence my relationships with students? How does it affect my teaching belief systems? To what extent do I become using Rancière's term, an 'ignorant school master'?

My encounter with Rancière inspired me to make the conscious decision to attempt to unlearn or change my belief system with respect to teaching and learning, a belief system that was founded on assumptions of intellectual inequality (Chapter 2). To accomplish this transformation I chose to embark on a journey to a place of "ignorance" that would incite change in my practice. Throughout this inquiry I have grappled with what it means to be "ignorant". From a Rancièrien perspective, there are perhaps relative degrees of ignorance; the most obvious being a teacher who teaches what they do not know. In this inquiry, I could not honestly claim this position. Even though I did not know where student's questions may lead them and I do not purport to know all there is about Earth and Space Science, I do have a base of knowledge in this area from my own education and teaching experience with this grade level. However, Rancière proposes other degrees of "ignorance"; one being not faking ignorance to provoke knowledge but being the "cause of knowledge" for students without actually transmitting any knowledge (Chapter 2). That is, being a *will* that instructs the student to activate the capability that they already possess. Another degree of "ignorance" is refusing the knowledge of inequality by rejecting the premise that it is necessary to begin with inequality in order to reduce inequality. Through my encounter with Rancière, and my journey through the experiment, my "ignorance" might be seen as in the process of reflecting the last two domains.

Striving for Rancière's philosophical ideal of believing in intellectual equality of all people meant moving towards a place of ignorance that *was* and *will continue* to be an ongoing process for me. In this study, my movement on this continuum did positively impact my practice and the science learning experiences for my students. The emergent model illustrates the move from a more teacher-centered classroom, rich in explicative practices to a more student-centered learning environment. Prior to the study, I believed that the former perpetuated 'intellectual helplessness' among students. The data analyzed (Chapter 7) provides evidence of the latter environment re-awakening students to their ability to exercise their own intelligence. Students developed a sense of liberation as they gained confidence in their own abilities and shifted from a general *"I can't do it"* attitude to an *"I can do it"* attitude. By doing less 'teaching' and focusing on asking more questions based on Rancière's taxonomy of questioning, invited students to think critically, analyze information, and lead their own learning journey.

It is interesting to reflect on the fact that as this learning occurred, a model of pedagogy emerged. The word "pedagogy" is derived from the Greek words *pais* or *paidos* meaning "child" and *ago* which means "lead", therefore, "to lead the child". Powers (2010) commenting on Rancière notes, "Rancière is critical of the term "deeming it tainted by its association with the division between passive student and master explicator . . . " (p. 5). In fact, critics may see my model as reproducing relations of domination. For example, Ellsworth (1989) argues that strategies that promote student "empowerment" do not address the institutionalized power imbalances such as the teacher-student relationship, and give the illusion of equality. However, I believe that the model is a reflection of a different discourse in action. It is a discourse about emancipation that does not start with a fundamental intellectual inequality in the teacher-student relationship. This discourse does not view emancipation as an act from the outside through which individuals are made equal, and the aim is not social emancipation (Chapter 2). In this respect, my study was not an attempt to re-define my pedagogy and relationship with students for utopian moments of equality. Rather, the intent being to interrupt the existing power relations in my classroom to create an environment to foster intellectual emancipation in science inquiry.

I entered into this inquiry acknowledging the power dynamic in the teacher-student relationship that in reality is predicated upon socially constructed and institutional authority. The students and I understood that, in our journey towards intellectual emancipation, the reality of this authority remained. Even Rancière recognizes that there is still an authority within emancipatory education. However, he asserts that it is an authority that is not based on a difference in equality. As Biesta (2010) notes, the teacher is only an authority in the sense that they set the "ignorant" person down a path of learning by instigating a capacity they already possess.

My model provided a structure in which I could use my institutional authority to create and protect a space to foster the idea of intellectual equality as students learned. It is a framework from which to start to exercise Rancière's educational tenants in the context of science inquiry at a particular point in time in my classroom.

8.2 Limitations of the Study

This research draws its data from the practices of one class and their teacher-researcher. The small sample size was well suited for my inquiry as a case study. The case study provided an opportunity to intimately witness the intervention so as to draw out insights that can contribute to the discussion of science inquiry and literacy in schools. Given that it did not involve a wide and diverse sample of teachers (in terms of age group, gender, experience in teaching science, and educational background), nor a wide range of classes (as in demographic constitution) and different schools, there is no claim that the findings are representative of or generalizable across all teachers, classes, or schools. Much of the data used to infer evidence of intellectual emancipation and science learning experiences was drawn from the analysis of interviews, discourses between me and the students, science journal reflections and responses. It must be recognized that this evidence came from what students were willing and/or able to articulate. For example, it cannot be assumed that the learning demonstrated by some students was also taking place with other students. Additionally, there might also be other unspoken perspectives and views that could have altered the conclusions drawn in this study. If left unspoken they could not be accessible as a resource. However, considerable effort was taken to use multiple sources of data, such as, observation through video, the use of questionnaires, self assessment tools and student artifacts to triangulate the information used for drawing conclusions.

8.3 Recommendations

Inquiry is widely advocated in practice, research and policy. My general recommendation or appeal to classroom educators is to challenge the dominant approach to inquiry in school science as hands-on and to recognize the value of inquiry as minds-on and for the development of the whole learner. The synergistic effect of combining the concepts of inquiry, reading, and intellectual emancipation was made possible by my attempt to break the pattern of student stultification in my classroom. This was done by creating a learning space that adopted a more dynamic view of inquiry, valued student's personal growth, and embraced democratic opportunities for all students to follow their own questions, create their own knowledge and learning experiences. By reading quality texts on a variety of science topics and choosing to apply their own relevant reading strategies, students not only broadened their domain knowledge of science but also realized their capacity to learn by using their own intelligence. This is especially poignant for English language learners who participated as fully equal learners.

With a focus of the study on the reading of science texts from different sources, future studies could investigate this type of inquiry with an exclusive focus on the access and reading of electronic texts from the Web. Such studies may evaluate any differences with students' experiences with reading as inquiry, their relationship to the text and authors. My study took place in a school comprised of linguistically and culturally diverse students whose recently immigrated parents made sacrifices for their children's education. As a result, the value for education and students' work ethic is quite strong. These characteristics are not reflective of all learning environments in classes and schools.

For other students and teachers to benefit from this work, those in the field of science education, scholarship, and research, need to encourage others who might use Ranciere's work to broaden the research paradigm. That is, to engage with Ranciere's notion of equality and politics to provide science educators with new political possibilities (Bazzul, 2013; Latther, 2012).

8.4 Final Words

In *The Ignorant Schoolmaster*, Rancière offered an abstract, decontextualized account of intellectual emancipation through the story of Jacotot. Decontextualized in the sense that he did not discuss the intricacies of how Jacotot and his students lived out their classroom experiences. The work does not easily translate to educational practice or policy because he does not promote a method for social transformation through the institution of schooling. I believe that Biesta (2010) commenting on Rancière best encapsulates the spirit of my action research study when he comments:

> To act on the basis of the assumption of equality requires a constant verification of it – not in order to check whether the assumption is true in the abstract, but in order to practice the truth of the assumption that is to make it true in concrete situations. What matters, therefore, is not that we are committed to equality, democracy and emancipation, but how we are committed to these concepts and how we express and articulate this commitment (p. 57).

The choice of my grade six science class to conduct the intervention was influenced by my desire for praxis; a stance influence by Dewey who recognized the importance of a pragmatic philosophical approach to ones practice. The essay by Christou and Bullock (2012) reminds all education stakeholders to embrace a philosophical disposition towards pedagogy. Their argument made me more confident to approach my study problematic with an orientation towards philosophical mindedness, which at its core is critical reflection and philosophy in action. They make the case that we have a responsibility to our students and colleagues to question established beliefs or practices as wisdom is sought, even when we assert a philosophical position that is tentative and contextually bound.

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APPENDICES

Appendix A
Parent/Guardian Informed Consent Letter

YORK UNIVERSITY, FACULTY OF EDUCATION
And Peel District School Board
Parent/Guardian Informed Consent Letter

Date: March 30, 2009

Dear Parent or Guardian,

My name is Lorraine Otoide, and I am an elementary school teacher at Floradale Public School as well as a graduate student in the Graduate Program in Education at York University. I am working towards my doctorate in Education in Language, Culture and teaching, and I am fulfilling the requirements by working on a major research study titled: "The Journey Towards Intellectual Emancipation Through Inquiry Science, Writing and the Use of First Language as a Learning Resource."

As part of my research study, I wish to invite your child to participate in a teacher research project involving our Grade 6 class. While we explore the science topic *Space*, I wish to investigate the use inquiry science, writing and the use of first language as a learning resource in the curriculum activities of the science classroom.

I ask your permission to use your child's words from our conversations, his or her drawings, writing, and other sample work, and to take photos and video of your child engaged in project work. Conversations with students will be audio-taped and transcribed, so I can recall what was said. Your child will be interviewed (approximately 15 minutes) by me to give them the opportunity to provide information about their learning experience and the interview will be audio taped and transcribed for research analysis.

As I write my research dissertation, I ask your permission to use your child's words, interview responses, drawings, writings, or copies of these in my paper and/or in any resulting presentations or publications. No information that identifies your child personally will appear in these works. To keep all identities confidential, I will use pseudonyms to refer to your child, her/his classmates, our school, and our board.

The science unit will run for approximately one term as per the requirement of the science curriculum. Your child will be engaged in regular school activities, and there are no anticipated risks to your child's participation. The primary reason for my study is to contribute to the knowledge of teaching and learning in science and further develop practices that will provide equitable learning environments that better serve the needs of English Language Learners and students in general.

All research participation is voluntary, and your child, or you on her/his behalf, may choose to withdraw from the study at any time. Your child

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would continue to participate in the activities, which are a part of our regular class routine, but I would not use her/his work as part of my research study.

If you have questions about the research in general or about your child's role in the study, please feel free to contact me at (lorraine.otoide@peelsb.com or (905) 275-1090), or my supervisor, Dr. Steve Alsop at 416-736-5018 (20665). This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process, or about your child's rights as a participant in the study, please contact Ms. Alison Collins-Mrakas, Manager, Research Ethics, 309 York Lanes, York University (telephone 416-736-5914 or e-mail acollins@yorku.ca).

Sincerely,

Lorraine Otoide

Parent/Guardian Consent

1. Consent for Participation

I, Mr & Mrs Amoako - Boatey (Name of parent/ guardian), consent / do not consent *(circle one)*

for my child, Joshua A-Boatey (Name of child) to participate in this study.

J A Boatey — Signature of parent or guardian — March 30/09 — Date

Joshua Amoako-Boatey — Signature of participant — March 30/09 — Date

[signature] — Signature of researcher — March 30/09 — Date

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Appendix B
Student Assent Form

YORK UNIVERSITY, FACULTY OF EDUCATION
And Peel District School Board
Student Assent Form

Date: March 30, 2009

Title of Study: The Journey Towards Intellectual Emancipation Through Inquiry Science, Writing and the Use of First Language as a Learning Resource

Investigator: Lorraine Otoide

Why I am doing this study?
While we explore the science topic of *Space*, I wish to investigate the use of inquiry science, writing and the use of first language as a learning resource in the curriculum activities of the science classroom.

The main reason for my study is to contribute to the knowledge of teaching and learning in science and further develop practices that will provide equitable learning environments that better serve the needs of English Language Learners and students in general.

What will happen during the study?
While we explore the science topic of *Space*, you will be engaged in regular school activities. I ask your permission to use your words from our conversations, drawings, writing, and other sample work, and to take photos and video of you when engaged in project work. Some of our conversations will be audio-taped and transcribed, so we can recall what was said.

Who will know about what I said or did in the study?
Results of this study will be distributed in academic journal articles and conference presentations, however, no information that identifies you personally will appear in any papers or publications resulting from this study. To keep your identity confidential, I will use pseudonyms to refer to you, the school, the board, and any persons to whom you many refer.

What if I have questions about the study?
You can ask me any questions you have about the study and I will answer them. If you have any questions later on you can always ask me before class or during breaks.

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Can I decide if I want to be in the study?
You can decide if you want to be in the study or not. It is OK if you say that you do not want to be in the study. It is also OK if you say yes now, but change your mind later.

If you are not in the study, you will still do the activities in our science unit but I won't use any of the work that you do in my project.

Verbal Assent:

I was present when Mrs. Otoide read this form (or had it read to her/him and gave verbal assent.

Mrs. Otoide
Person who obtained assent

Joshua Amoako-Boateng
Signature

03/30/09
Date

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Appendix C
York University Ethics Approval

YORK UNIVERSITÉ UNIVERSITY

Certificate #:	**STU 2009 - 042**
Approval Period:	**03/26/09-03/26/10**

OFFICE OF RESEARCH ETHICS (ORE)
309 York Lanes
4700 Keele St.
Toronto ON
Canada M3J 1P3
Tel 416 736 5914
Fax 416 736 5837
www.research.yorku.ca

Memo

To: Lorraine Otoide, Faculty of Education
Lorraine.otoide@peelsb.com

From: Alison M. Collins-Mrakas, Sr. Manager and Policy Advisor, Research Ethics
(on behalf of Daphne Winland, Chair, Human Participants Review Committee)

Date: **Thursday 26th March, 2009**

Re: Ethics Approval

The Journey Towards Intellectual Emancipation Through Inquiry Science, Writing and the Use of First Language as a Learning Resource

I am writing to inform you that the Human Participants Review Sub-Committee has reviewed and approved the above project.

Should you have any questions, please feel free to contact me at: 416-736-5914 or via email at: acollins@yorku.ca.

Yours sincerely,

Alison M. Collins-Mrakas M.Sc., LLM
Sr. Manager and Policy Advisor,
Office of Research Ethics

Appendix D

Array of Pictures Representing Teaching and Learning

Appendix E
Science Portfolio Reflection Questions

Visi

Science Portfolio Reflection Questions

[illegible]

I selected my Time Travel artifact. Why? Because I think lots of people will be attracted to this phenomenon, I know Mrs. Obode will. I find this topic particularly to be my most interesting and most researched.

[illegible]

I benefited from this way of learning because I got to research questions I found interesting. I got to research (myself) and find the answers to the questions I have yearned for. It also gives me a sense of accomplishment (I am not bragging).

[illegible]

This way of learning influenced how I learned. It is a new, different way. This way of learning earns you more knowledge. You research heavily on questions you want to find the answers to. (See ↓ box for more)

[illegible]

This way of learning caused me to think outside the box. Usually, teachers give you set questions to find set answers for. In this, we got to think of unique questions, research heavily and find detailed answers to.

[illegible]

This/my learning may help the community in the future because I can spread knowledge. Everybody will gain new information, it will have a boomerang effect.

Appendix F
Research Process Rubric

Research Process Rubric – Elementary

This rubric may be used for self-assessment and peer feedback.

CATEGORY				
Research Questions	3 points	2 points	1 point	0 points
	☒ Wrote clear, creative and interesting questions which fit the topic.	☐ Wrote clear questions which fit the topic.	☐ Wrote some questions which did not fit the topic.	☐ Wrote many questions which did not fit the topic.
Selection of Sources	3 points	2 points	1 point	0 points
	☒ Identified useful sources in many formats (books, magazines, electronic).	☐ Identified mostly useful sources in many formats (books, magazines, electronic)	☐ Identified a few useful sources in one or two formats.	☐ Identified no useful sources in any format.
Note-taking & Keywords	3 points	2 points	1 point	0 points
	☒ Located and recorded information which answered all of the research questions.	☐ Located and recorded information which answered most of the research questions.	☐ Located and recorded a lot of information that did not directly answer the research questions.	☐ Located and recorded incomplete information which failed to answer any of the research questions.
	☐ Organized neat, easy to read notes.	☒ Organized notes and most were neat and easy to read.	☐ Failed to organize notes effectively; many were messy and hard to read.	☐ Did not organize notes; all notes were messy and hard to read.
	☒ Wrote all notes using own words and key facts.	☐ Wrote most notes using own words and key facts.	☐ Wrote some notes that were copied word-for-word from the source.	☐ Copied most or all of the notes word-for-word from the source.
	☒ Selected effective keywords.	☐ Selected mostly effective keywords.	☐ Selected many keywords that were not effective.	☐ Selected no effective keywords.
Sharing and Presenting Information	3 points	2 points	1 point	0 points
	☒ Presented all information in a clear and organized way.	☐ Presented most of the information in a clear and organized way.	☐ Presented information which was poorly organized or was difficult to understand some of the time.	☐ Presented information which was poorly organized, hard to understand.
	☐ Selected a highly effective and creative format for the presentation.	☒ Selected an effective format for the presentation.	☐ Selected a format which was only minimally effective for this topic.	☐ Selected a format which was not effective for this topic.
Listing Sources	3 points	2 points	1 point	0 points
	☒ Included all sources used and listed sources in the correct format.	☐ Included most sources used and listed sources in the correct format.	☐ Included most sources used, but some information was missing or incorrect.	☐ Failed to include most of the sources used, and a lot of the information was missing or incorrect.
				/15

Appendix G
Interview Questions

Science Interview Questions

- This term in science we tried Jacotot's way to explore a different way of learning.
- At the start of the term I introduced the class to Jacotot's story and some of his ideas about teaching and learning. He believed that students have the ability to learn through their own intelligence, without a teacher's explanations.
- We also talked about equality, that is, You = Me = Each Other = Text you are reading.

So…

1. How did you find this approach different from the ways you are use to learning science? (Some examples?)
2. I want you to think about what it means to be a science learner before I ask you the next question. (Comments?)
3. How would you describe yourself as a science learner at the beginning of the year? (ex. What you did, what you thought about how you should learn)
4. How do you see yourself now? Same of different? If different: Why do you think it changed?
5. I would like you to finish this sentence – I am a science learner because….

At the beginning of this term, as a class we talked about using a first language to help science thinking and to help express what you learned. Some people in the class said that they use their first language to think first, and then translate to English. Are you one of those people?

If NO: Do you have a L1? Do you use your L1 at all to help you learn anything? (school or other)

If YES:

1. How do you use your L1 in your learning? (can be in your head)
2. What is your L1?

I notice that you chose not to use your first language.

3. What was the reason for that?
4. Do you find it easier to use L1 in some subjects more than others? (If so, what are those subjects?)

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